Science Compliance
Fluids Basis Experiments
Fluids Real Experiments

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Compliance Summary for Fluids Basis Experiments

BASIS EXPERIMENTS	f1	f2	f3	f4	f5	f6	f7	f8	f9	f10	f11A	f11B	f11C	f12	f13A	f13B	-- f14 --	f15A	f15B	------- f16 ------
Comply w/ SRED			X												X					
RESOURCES to comply:																				
Hardware																				
Bench Volume																				
Exp Environment																				
Data																				
Mass																				
Power																				
Energy																				

Science Requirements Envelope Document (SRED)
Appendix A
Appendix E

Color Code: ≡ Basis Experiment related ≡ *Real Experiment related*
≡ Comply ≡ Caution

Compliance Summary for Fluids Basis Experiments and *Real Experiments*

BASIS EXPERIMENTS	f1	f2	f3	f4	f5	f6	f7	f8	f9	f10	f11A	f11B	f11C	f12	f13A	f13B	-- f14 --	f15A	f15B	------- f16 ------
Comply w/ SRED			X												X					

RESOURCES to comply:

Hardware
Bench Volume
Exp Environment
Data
Mass
Power
Energy

Science Requirements Envelope Document (SRED)
Appendix A
Appendix E

																GFM				LMM			
REAL EXPERIMENTS		C/L														Pool Boil	µgSEG	SiGMA	MOBI	FOAM	LΦCA	CVB	PHaSE-2	PCS-2
Accommodate																		?						

RESOURCES to accommodate:

Hardware
Bench Volume
Exp Environment
Data
Mass
Power
Energy

Real Experiments are in various stages of development

Color Code: ≡ Basis Experiment related ≡ *Real Experiment related*
≡ Comply ≡ Caution

Compliance Summary for Fluids Basis Experiments and *Real Experiments*

BASIS EXPERIMENTS	f1	f2	f3	f4	f5	f6	f7	f8	f9	f10	f11A	f11B	f11C	f12	f13A	f13B	-- f14 --	f15A	f15B	------- f16 ------
Comply w/ SRED			X												X					
RESOURCES to comply:																				
Hardware																				
Bench Volume			X												X					
Exp Environment																				
Data																				
Mass																				
Power																				
Energy																				

																	GFM				LMM			
REAL EXPERIMENTS		C/L														Pool Boil	µgSEG	SiGMA	MOBI	FOAM	LΦCA	CVB	PHaSE-2	PCS-2
Accommodate																		?						
RESOURCES to accommodate:																								
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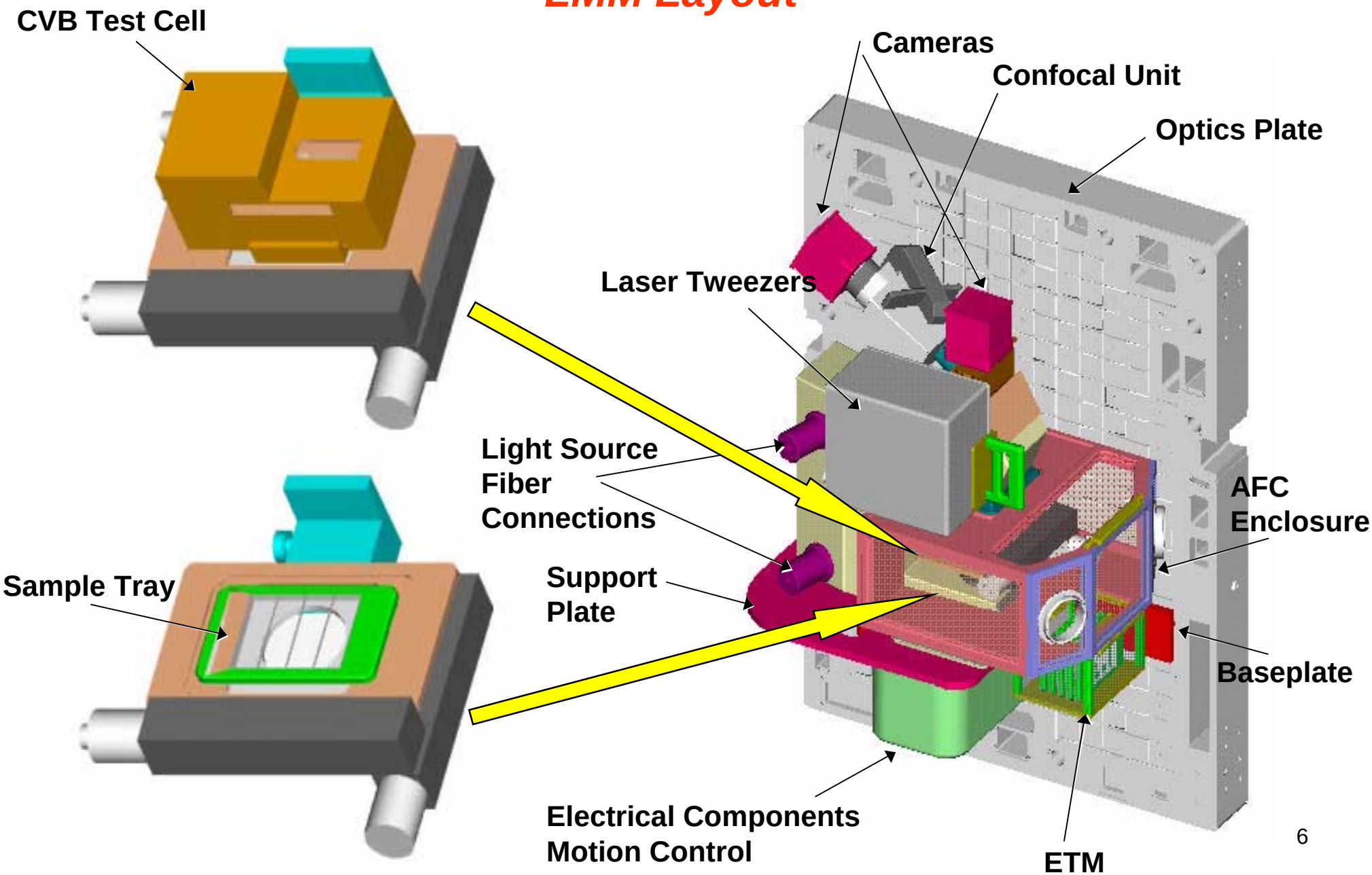
Color Code: ≡ Basis Experiment related ≡ *Real Experiment related*

≡ Comply ≡ Caution

LMM – Light Microscopy Module

- *CVB ≡ Constrained Vapor Bubble*
- *LΦCA ≡ Low Volume Fraction Extropically Driven Colloid Assembly*
- *PHaSE-2 ≡ Physics of Hard Spheres Experiment-2*
- *PCS-2 ≡ Physics of Colloids in Space-2*

LMM Layout


CVB Test Cell
Cameras
Confocal Unit
Optics Plate
Laser Tweezers
Light Source
Fiber
Connections
AFC
Enclosure
Sample Tray
Support
Plate
Baseplate
Electrical Components
Motion Control
ETM

LMM – Constrained Vapor Bubble (CVB)

Experiment Science Summary

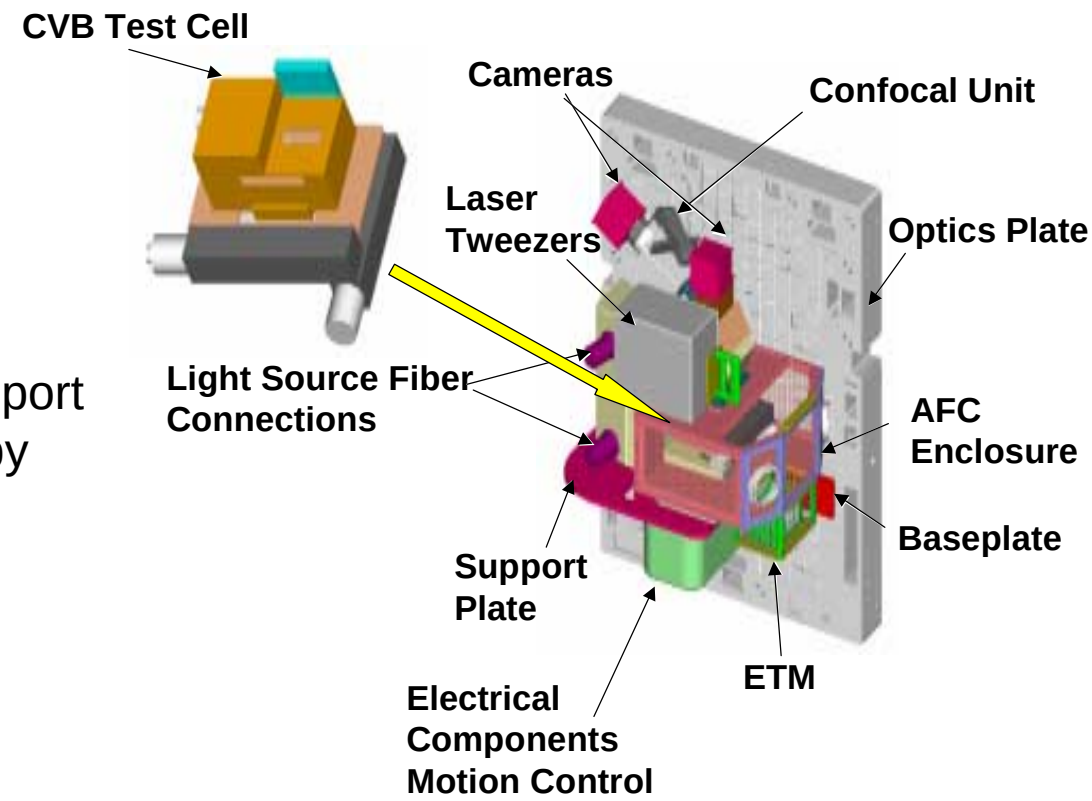
- PI: Pete Wayner (RPI)
- PM: Susan Motil (GRC)

Experiment Summary

- Phase Change at an Interface -- Study of the heat and mass transport mechanisms that are controlled by interfacial phenomena.

Key FIR - Experiment Interface Requirements

- Micro-gravity environment



Compliance Summary: FCF design accommodates all CVB interface requirements. The impact of G-jitter from within the FIR and from ARIS start-up under study. ARIS might not be required.

CVB – Compliance Matrix

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
Hardware	Film Thickness FOV: 100-150 micron Resolution: TBD Frame Rate: 30 fps	UHFR camera (FCF BSD B.2.3.5.3.1.3)	Leica Microscope	Yes – FCF UHFR camera under evaluation; LMM has back-up if needed
	Macroscopic View FOV: 60mm Resolution: Std. Video Frame Rate: 30 fps	Analog camera (FCF BSD B.2.3.5.3.1.2)	Lens	Yes
	Processing: Film thickness measurement	IPSU (FCF BSD 5.2.5)	Analysis algorithm	Yes
	Tracking/Positioning: Focusing of the microscope	FSAP/IPSU (FCF BSD B.2.3.7, FCF BSD 5.2.5	Focus algorithm	Yes – If timing is too long from FSAP to IPSU to control focusing, then LMM can purchase a DSP card for the FSAP (duplicate the IPSU DSP)
	Epi-Illumination Wave length: 543nm and another 543 + or – 100nm.		Mercury vapor light	Yes – Light will interface to a FIR GPI (FCF BSD B.2.3.3.3). LMM/CVB will utilize a metal halide light if FIR develops one

CVB – Compliance Matrix – Continued

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
Experimental Environment (measurement and control)	Acceleration measurement	SAMS (FCF BSD 5.1.4)		Yes
	Acceleration control G/G_0: DC: As available Jitter: TBD	ARIS (FCF BSD 5.3)		Yes – ARIS might not be required
	Microscope Motors control	FSAP (A/D) (FCF BSD B.2.3.7)	LMM Avionics	Yes – Motor control cards provided by FIR & LMM. Command signals from FSAP
	Heater/Cooler control	FSAP (FCF BSD B.2.3.7)	Sample heater/cooler	Yes
	Temp measurement: 38 Thermocouples at TBD Hz 1 Thermistor/TBD Hz	FSAP (A/D) (FCF BSD B.2.3.7) FSAP (FCF BSD B.2.3.7)	T/Cs, multiplexer, signal conditioning Sensor and board	Yes – Data is fed into FSAP A/D cards (FCF BSD B.2.3.7) Yes
	Pressure measurement: 1 @ once per 2 min. Voltage measurement: Health & status	FSAP (A/D) (FCF BSD B.2.3.7) FSAP (A/D) (FCF BSD B.2.3.7)	Pressure Transducer	Yes Yes

CVB – Compliance Matrix – Continued

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
	Air: Bulk heat removal – 275W Water: Sample cooler	ATCS (FCF BSD 5.2.1) Moderate Temp. Loop (FCF BSD 5.2.2)	 Isolation valves	Yes Yes
	Vent to assist in clean up	Vent Resource (FCF BSD 3.0)	Control valves	Yes
	Atmospheric monitoring	AMA (FCF BSD B.2.3.10)		Yes
Data	Total data: 9.4 GB Post test: Yes	IOP (FCF BSD 5.2.4) IOP/ISS HRDL (FCF BSD 3.0, 3.3, 5.2.4) Same		Yes Yes
	"Real time" Up/Down link	IOP (FCF BSD 5.2.4) IOP/ISS HRDL (FCF BSD 3.0, 3.3, 5.2.4)		Yes

CVB – Critical Hardware Summary

FCF Provided	PI Provided
• FSAP* • Analog Camera • UHFR Camera • IPSU* • SAMS FF Head • AMA • ARIS	• Microscope/Mini-Facility • Microscope Avionics Package • Mercury Vapor White Light Source

Additionally, FIR is investigating a Metal Halide Lamp which could be used in place of LMM's Mercury Vapor Lamp.

*** Includes embedded software**

CVB – Mass and Stowage Estimates

Item	Component Stowage Volume (cm^3)	Mass (Kg)	# Utilized	# in Rack	# in Stowage
FSAP Main Section[1]			1	1	
PI FSAP	12,455	12.4	0	0	1
IPSUs[1]			1	2	
DCMs	4,341	3.3	0	0	4
Color Analog Controller	3,174	1.5	1	1	0
Color Analog Camera Head	48		1	1	0
Monochrome Digital IAM	1,515	0.9	0	0	2
UHFR Camera	1,674	2.0	1	1	0
Color Macro OM	1,429	1.5	0	0	1
Monochrome Macro OM	3,089	1.3	0	0	2
High Magnification OM	5,593	1.8	0	0	1
Dual White Light Source[1]			0	1	
White Light Panel (with bundle)	9,391	2.4	0	0	1
Nd:YAG Laser[1]			0	1	
Dual Laser Diode[1]			0	1	
25mm Collimator	270	0.2	0	0	1
50mm Collimator	917	0.8	0	0	1
Gimbaled Mirror	4,508	4.7	0	0	1
Translation Stage	1,980	5.2	0	0	1
Movable Mount	6,415	4.2	0	0	2
AMA			1	1	
SAMS FF Head	386	1.2	1	1	0

LMM - Core	325,000	83.0	1	1	0
LMM - ETMs	9,396	4.0	5	1	4
LMM - IOP Hard Drives			2	2	0
LMM - Monochrome Camera[2]			0	0	0
LMM - Mercury Vapor Lamp[2]			1	1	0

Mass

- Rack Operational: 752.7Kg

Volume

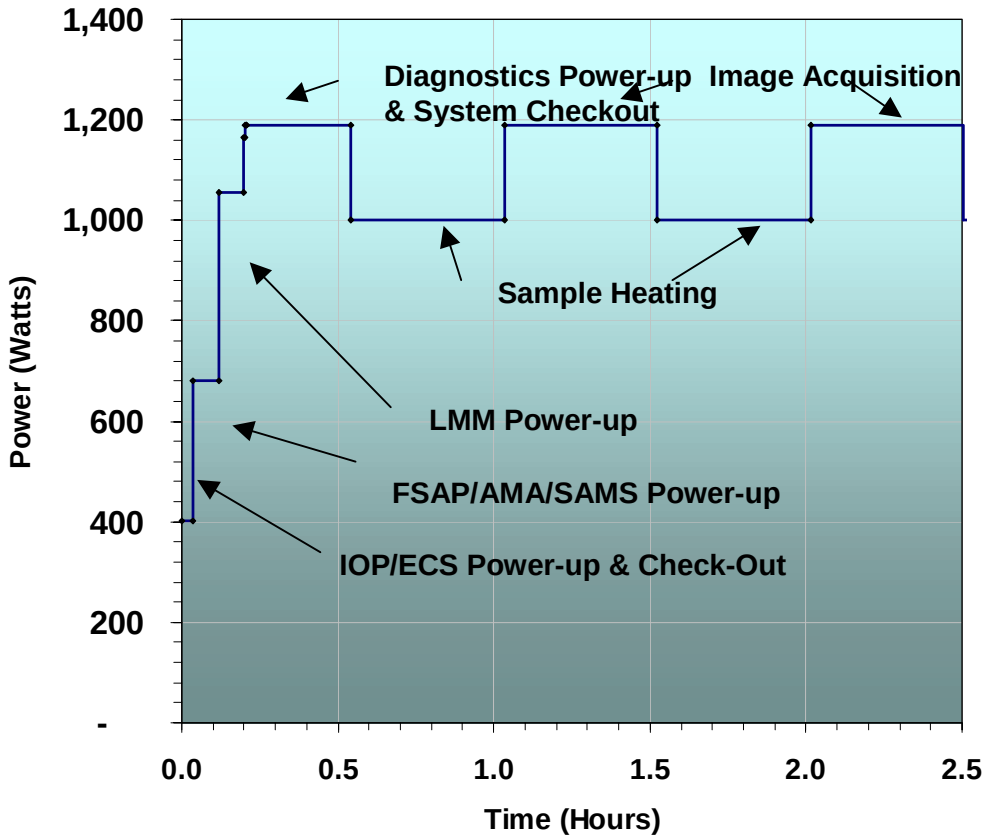
- Stowage Operational[4]: $0.148m^3$
- LMM Total Stowage[4]: $0.423m^3$

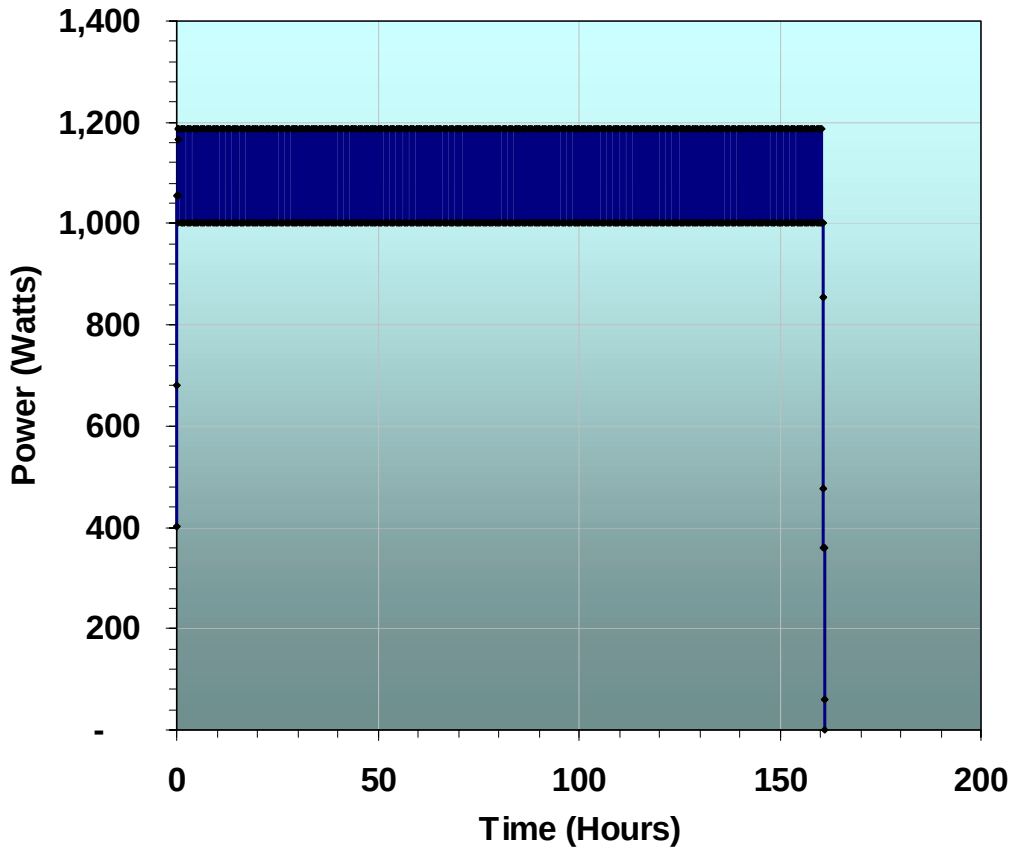
1 - Component is stored on back of bench (as standard interface)

2 - Mass & volumes are part of core mass & volumes

4 - Include 30% stowage material factor

CVB – Operational Power Profile





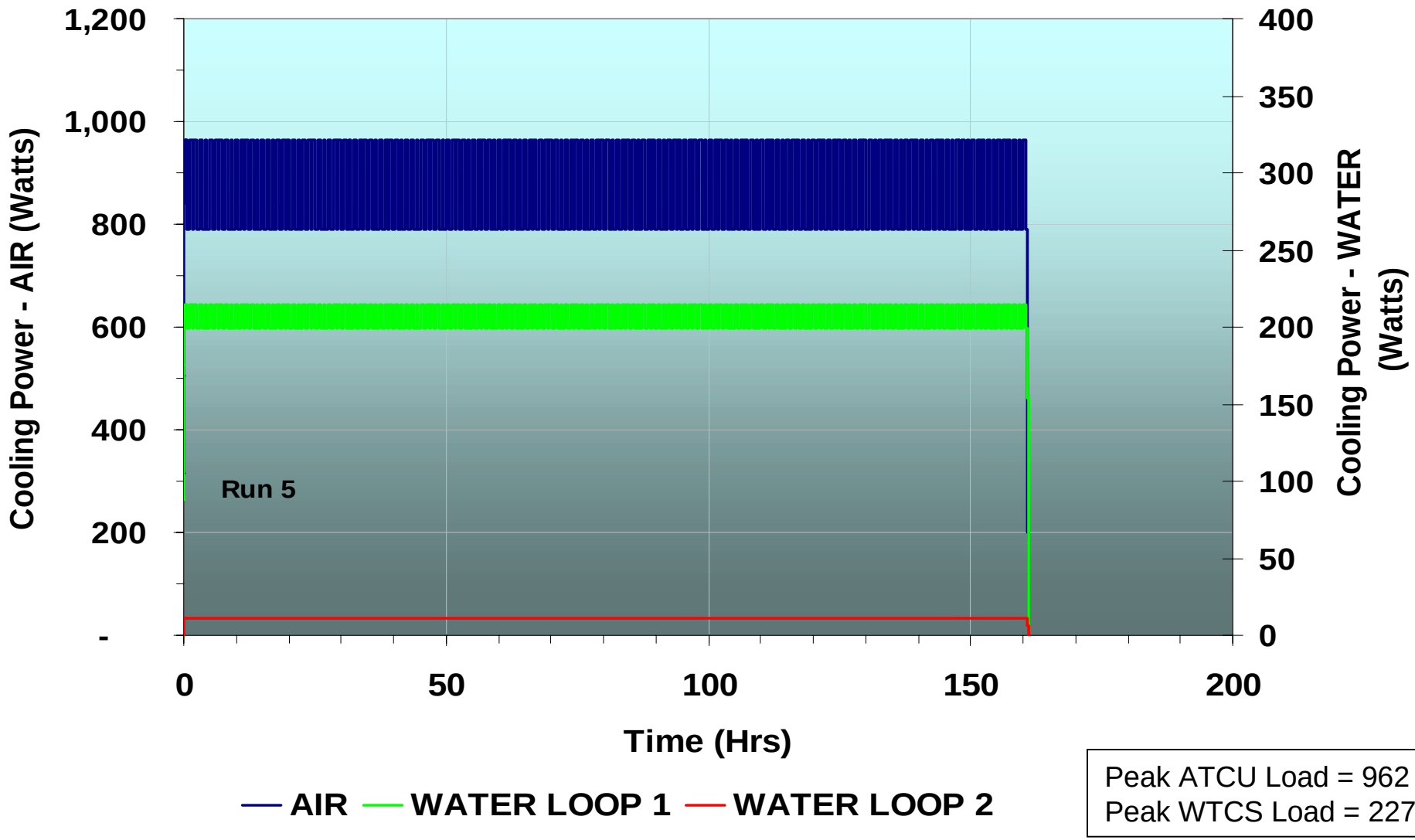
Assumptions:

- 10 runs: operational hrs/run = 34, 34, 80, 80, 80, 80, 80, 80,160,160 respectively
- Data points (image acq)/run = 15, 15, 83, 83, 83, 83, 83, 83, 164, 164 respectively
- 15MB per data point (34 seconds download per data point)
- 13 GB data total generated by experiment during ten runs
- Data Down linked after acquisition, during heating cycle (100% downloaded)

Peak Power = 1,189 W
Average Power = 1,090 W
Operational hours = 868
Total Energy = 950 kW-h

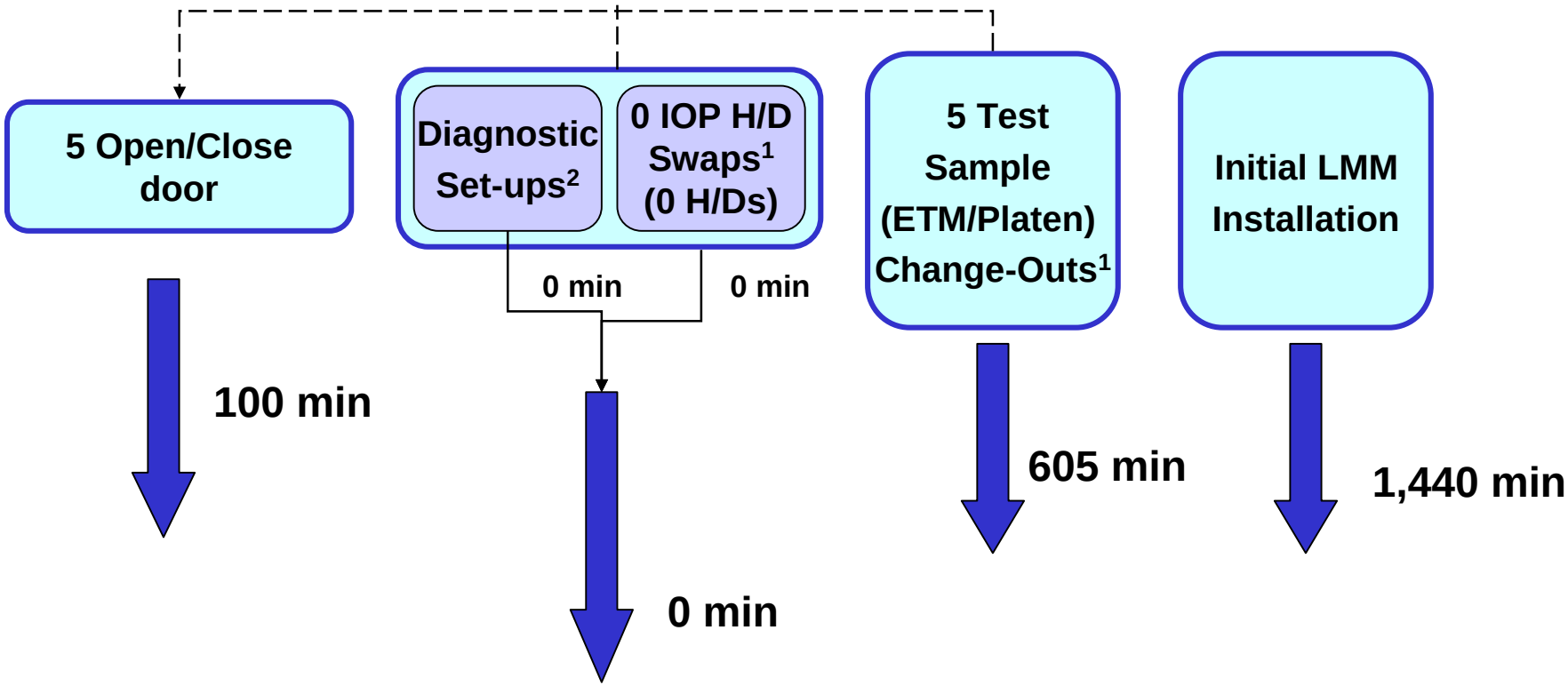
Peak ATCU Load = 962 W
Peak WTCS Load = 227 W

CVB – Environmental Control System (ECS) Load Profile



Peak ATCU Load = 962 W
Peak WTCS Load = 227 W

CVB – Crew Time



Total Crew Time
2,145 minutes (i.e. 35.8 hrs)

1 – HD Swaps and platen changes coordinated
2 – Part of Initial LMM Installation

LMM – Low Volume Fraction Extropically Driven Colloid Assembly (LΦCA)

Experiment Science Summary

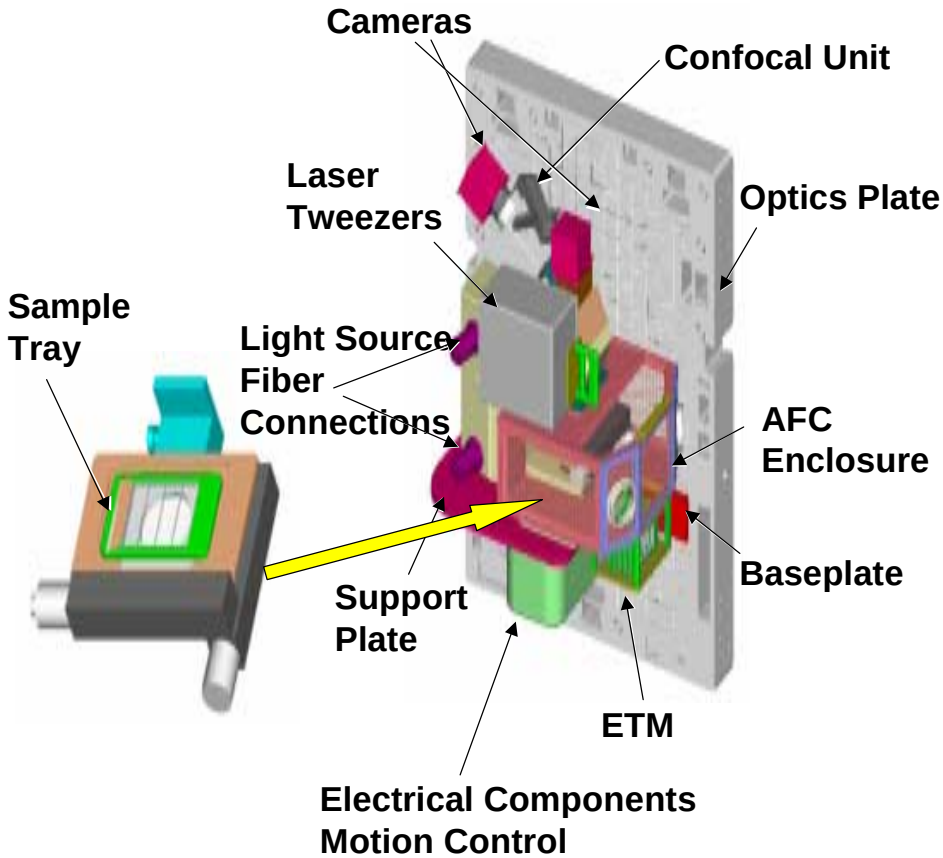
- PI: Arjun Yodh (University of Pennsylvania)
- PM: Susan Motil (GRC)

Experiment Summary

- Study nucleation & growth, on specific surface templates, of new and novel colloidal structures of industrial importance (e.g., photonic band-gap crystals) from low-volume-fraction binary particle suspensions.

Key FIR - Experiment Interface Requirements

- Micro-gravity environment
- Data management



Compliance Summary: FCF design accommodates all LΦCA interface requirements. Impact of G-jitter from ARIS start-up under study; ARIS might not be required. Data management within the experimental timeline is TBD.

LΦCA – Compliance Matrix

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
Hardware	Visual Images - Color (DIC, Bright field) FOV: 100 x 100µm; 2 x 2mm Resolution: 40nm Frame Rate: 30fps	Analog Camera (FCF BSD B.2.3.5.3.1.2)	Leica Microscope	Yes Yes – system issues could drive engineering solution to different camera.
	Surveillance FOV: 15cm Resolution: Std. video Frame Rate: 30 fps		Toshiba Color Camera (FCF BSD B.2.3.5.3.1.2), Fish eye lens	Yes – LMM to build another camera; FIR may take on this responsibility.
	Confocal Monocrhome FOV: 100 x 100mm; 1 x 1mm Resolution: 40nm Frame Rate: 30fps to several hundred fps	UHFR camera (FCF BSD B.2.3.5.3.1.3)	Leica Microscope	Yes Yes –FCF UHFR camera under evaluation; LMM has back-up if needed
	Confocal Light Source 532 nm Nd:YAG Laser	Nd:YAG Laser (FCF BSD B.2.3.5.4.1.2)		Yes
	Spectrophotometer Light Source 400-700nm (up to 1600nm desired)		TBD	TBD – LMM is considering FIR white light and other options.

LΦCA – Compliance Matrix – Continued

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
	Trans-Illumination White light	Halogen White Light (FCF BSD B.2.3.5.4.1.1)		Yes – If FIR switches to a metal halide light, then it would be used in place of the halogen.
	Spectrophotometer Dynamic range: 10000:1 S/N 16000/1 Full Scale S/N 1/1 at the low end		Leica Microscope Camera or Detector	Yes TBD – FCF Hi Res camera (FCF BSD B.2.3.5.3.1.1) may suffice.
	Processing: Centroid finding	IPSU (FCF BSD 5.2.5)	Analysis algorithm	Yes
	Tracking/Positioning: Focusing of the microscope	FSAP/IPSU (FCF BSD B.2.3.7, FCF BSD 5.2.5)	Focus algorithm	Yes – If timing is too long from FSAP to IPSU to control focusing, then LMM can purchase a DSP card for FSAP (duplicate the IPSU DSP)

LΦCA – Compliance Matrix – Continued

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
Experimental Environment (measurement and control)	Acceleration measurement	SAMS (FCF BSD 5.1.4)		Yes
	Acceleration control G/G_0: DC: 10^{-6} Momentary: 10^{-1} Jitter: 10^{-3} for freq < TBD Hz	ARIS (FCF BSD 5.3)		TBD – impact of jitter from ARIS start-up under study. ARIS might not be required
	Temperature: Internal to LMM Pressure: Atmospheric (internal to the FIR) Voltage: Detector intensity, health & status	FSAP (A/D) (FCF BSD B.2.3.7) Atmospheric Monitoring Assembly (FCF BSD B.2.3.10) FSAP (A/D) (FCF BSD B.2.3.7)	TCs/Thermistor and signal conditioning	Yes – Data fed into FSAP A/D cards Yes Yes – If a detector is used for spectrophotometer a LMM A/D board for the detector intensity may be required.

LΦCA – Compliance Matrix – Continued

System	Key Requirements	FCF	PI Hardware	Compliance
	Microscope Motors control	FSAP (FCF BSD B.2.3.7)	LMM Avionics	Yes – Motor control cards provided by both FIR and LMM; Command signals come from FSAP
	Vent to assist in clean up	Vent Resource (FCF BSD 3.0)	Control valves	Yes
	Air: Bulk heat removal – 300W	ATCS (FCF BSD 5.2.1)		Yes
	Thermal control of sample cell		TBD	TBD – This requirement may be deleted
Data	Total data: 11,900 GB (w/o compression)	IOP (FCF BSD 5.2.4)		Yes – LMM to use a combination of compression, data downlink and IOP removable hard drives
	"Real time": Yes	IOP/ISS HRDL (FCF BSD 3.0, 3.3, 5.2.4)		Yes
	Post test: Yes	Same		Yes

LΦCA – Critical Hardware Summary

FCF Provided	PI Provided
• FSAP* • Analog Camera • UHFR Camera • White Light Source • Nd:YAG 532nm Laser • IPSU* • SAMS FF Head • AMA • ARIS** ***Includes embedded software** ****Use of ARIS dependant on μg disturbance levels**	• Microscope/Mini-Facility • Analog Camera • Spectrophotometer • Microscope Avionics Package

LΦCA – Mass and Stowage Estimates

Item	Component Stowage Volume (cm^3)	Mass (Kg)	# Utilized	# in Rack	# in Stowage
FSAP Main Section[1]			1	1	
PI FSAP	12,455	12.4	0	0	1
IPSUs[1]			1	2	
DCMs	4,341	3.3	0	0	4
Color Analog Controller	3,174	1.5	1	1	0
Color Analog Camera Head	48		1	1	0
Monochrome Digital IAM	1,515	0.9	0	0	2
UHFR Camera	1,674	2.0	1	1	0
Color Macro OM	1,429	1.5	0	0	1
Monochrome Macro OM	3,089	1.3	0	0	2
High Magnification OM	5,593	1.8	0	0	1
Dual White Light Source[1]			1	1	
White Light Panel (with bundle)	9,391	2.4	0	0	1
Nd:YAG Laser[1]			1	1	
Dual Laser Diode[1]			0	1	
25mm Colimmator	270	0.2	0	0	1
50mm Collimator	917	0.8	0	0	1
Gimbaled Mirror	4,508	4.7	0	0	1
Translation Stage	1,980	5.2	0	0	1
Movable Mount	6,415	4.2	0	0	2
AMA			1	1	
SAMS FF Head	386	1.2	1	1	0
LMM - Core	325,000	83.0	1	1	0
LMM - ETMs	9,396	4.0	1	1	0
LMM - IOP Hard Drives[3]			2	2	8
LMM - Monochrome Camera[2]			0	0	0
LMM - Color Camera[2]			1	1	0
LMM - Spectrophometer[2]			1	1	0

Mass

- Rack Operational: 752.7Kg

Volume

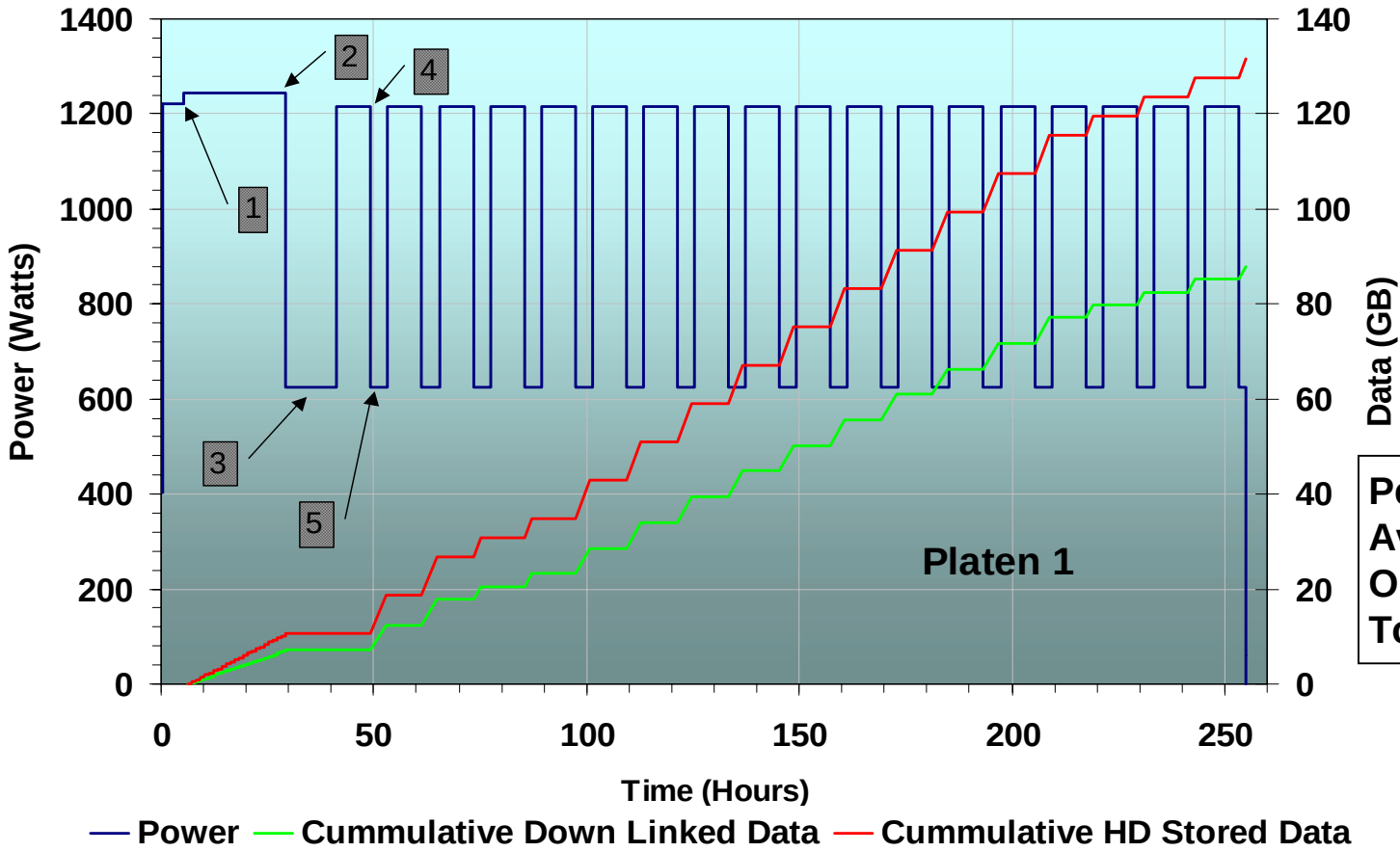
- Stowage Operational[4]: 0.108m^3
- LMM Total Stowage[4]: 0.423m^3

1 - Component is stored on back of bench (as standard interface)

2- Mass & volumes are part of core mass & volumes

4- Include 30% stowage material factor

LΦCA – Operational Power Profile



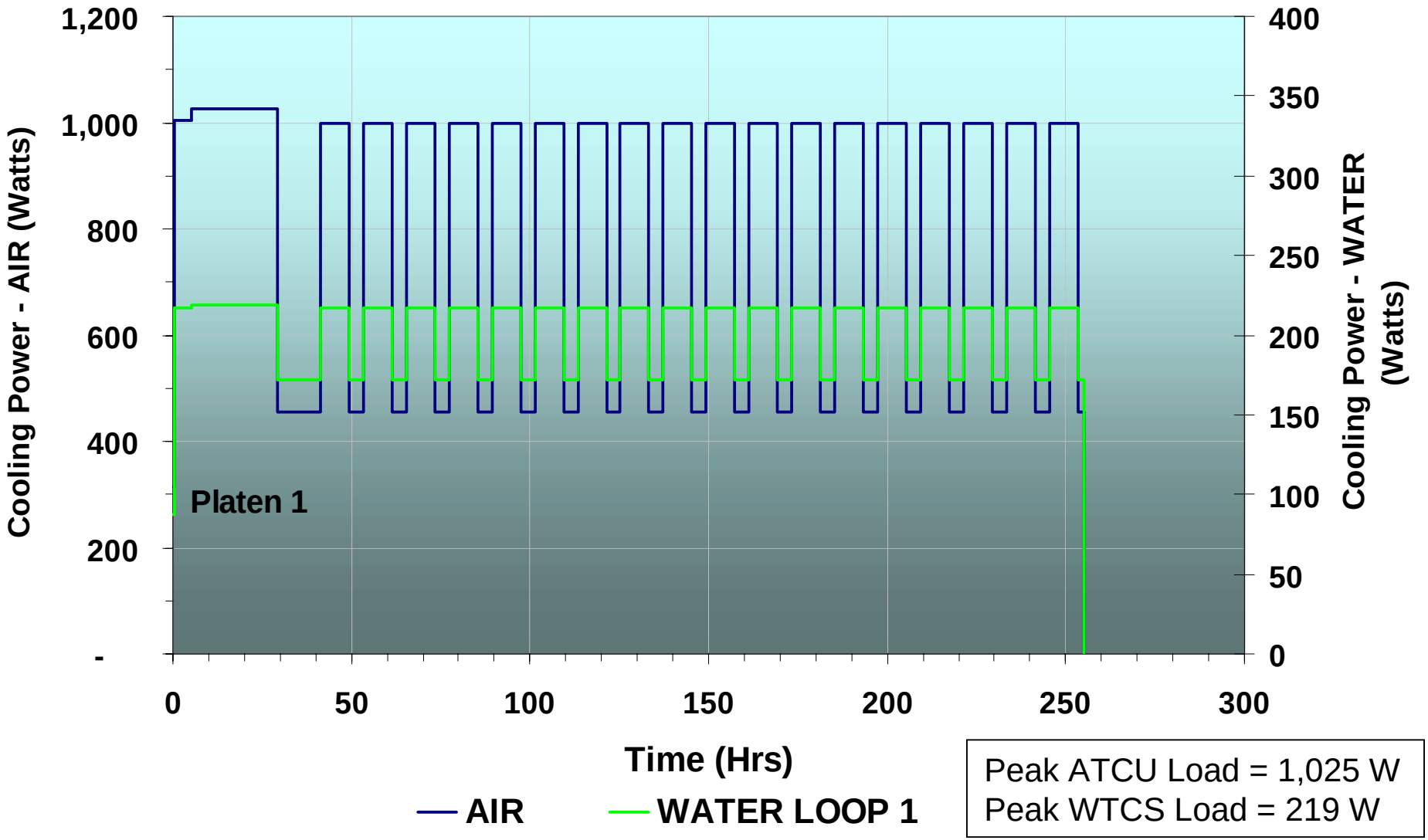
1 - Mixing Period
2 - Bright Field Imaging
3 - 1st Crystallization Period
4 - Confocal Imaging
5 - Downlink and Crystallization Period

Peak Power = 1,244 W
Average Power = 1,028 W
Operational hours = 1,276
Total Energy =1,312 kW-h

Assumptions:

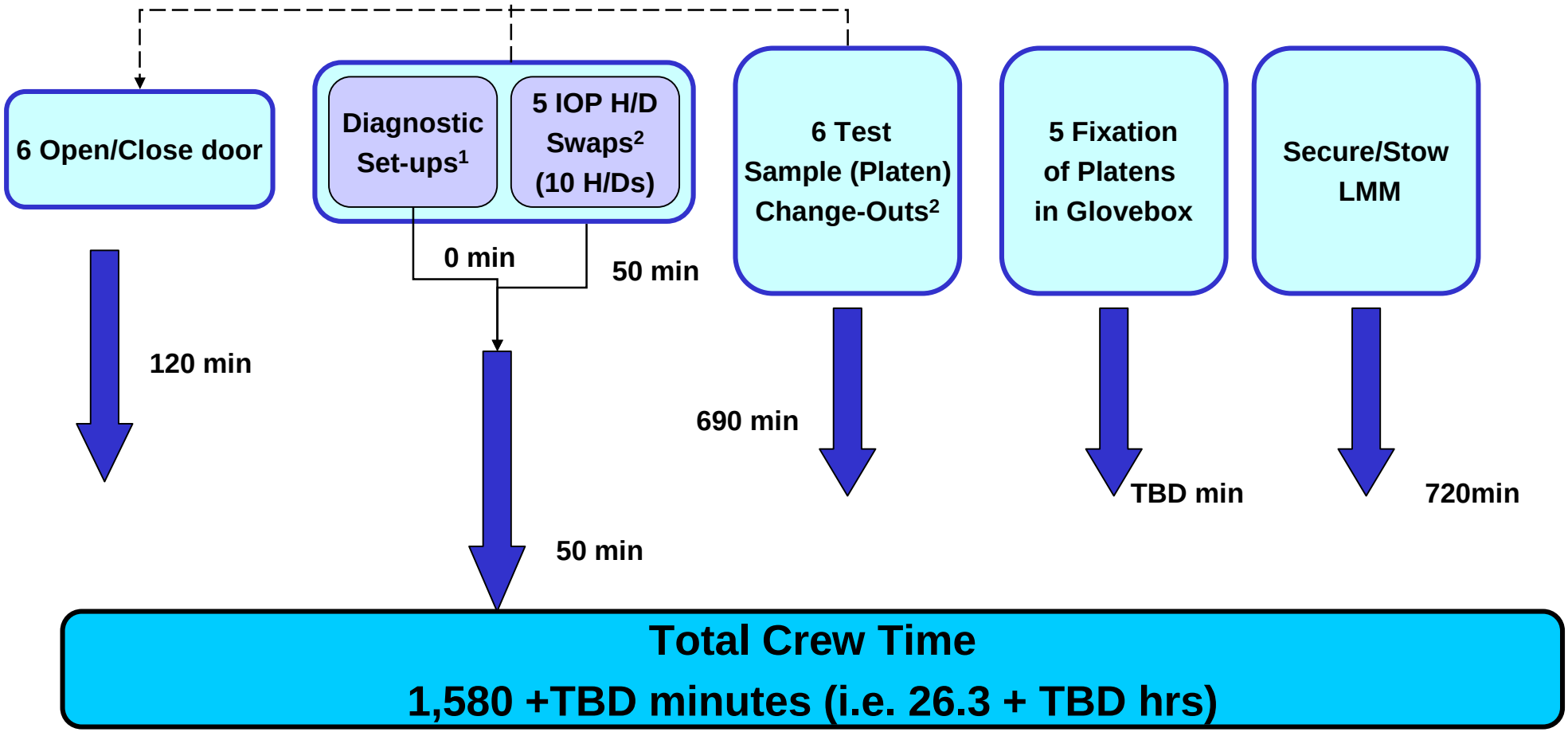
- 30% of raw BF/Confocal images down linked; 45% of raw BF/Confocal Images stored on HDs
- 100% of BF/Confocal images post processed & down linked (10,000:1 compression)
- 70 samples per platen
- 5 platens for a total of 440GB down linked and 659GB stored on HDs
- BF / Confocal images for 70 samples during 24 / 8 hour period(s)
- Fixation in Glovebox not included

LΦCA – Environmental Control System (ECS) Load Profile



Peak ATCU Load = 1,025 W
Peak WTCS Load = 219 W

LΦCA – Crew Time



1 – Diagnostics pre-configured from PHaSE-2/PCS-2
2 – HD Swaps and platen changes coordinated

LMM – Physics of Hard Spheres Experiment-2 (PHaSE-2)

Experiment Science Summary

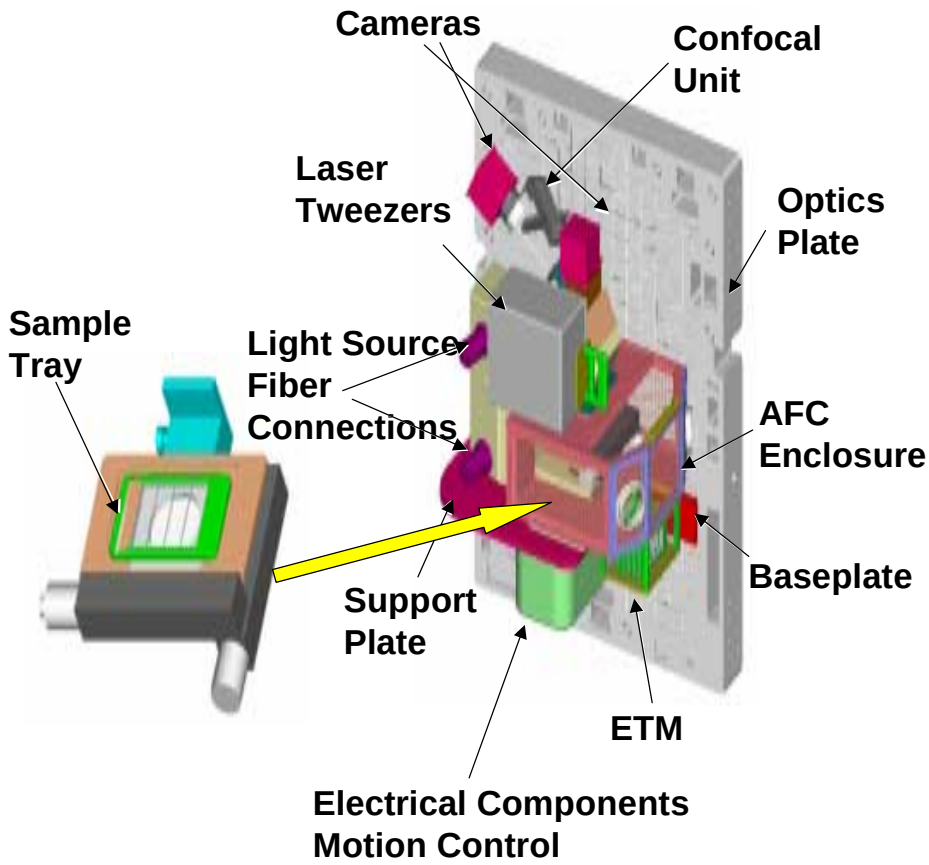
- PI: Paul Chakin (Princeton)
- PM: Susan Motil (GRC)

Experiment Summary

- Colloids -- Study nucleation and growth of crystal structures and rheological structural properties of hard sphere colloidal suspensions at various volume fractions and define their various transitions (liquid, crystalline, & glass states) and transitions regions.
- Study response to applied fields that force particles into non-equilibrium conditions.

Key FIR - Experiment Interface Requirements

- Control of micro-gravity environment
- Data management



Compliance Summary: FCF design accommodates all PHaSE-2 interface requirements. Impact of G-jitter from within the FIR and from ARIS start-up under study; ARIS might not be required. Data management within the experimental timeline is TBD.

LMM – Physics of Colloids in Space-2 (PCS-2)

Experiment Science Summary

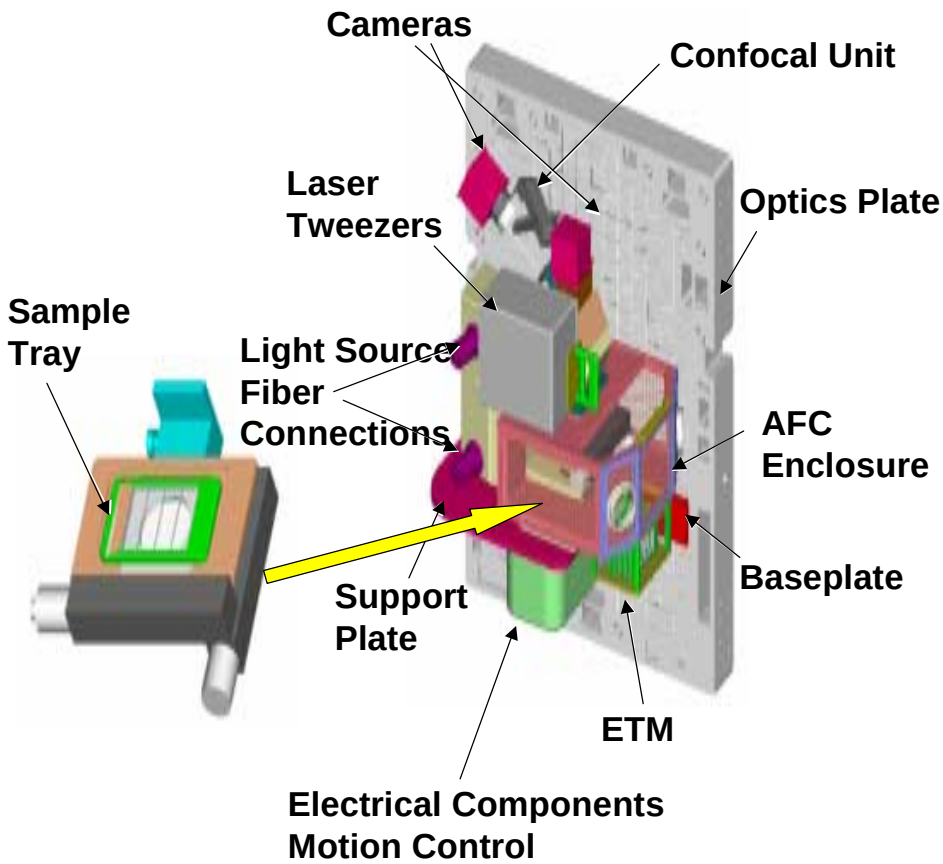
- PI: David Weitz (Harvard)
- PM: Susan Motil (GRC)

Experiment Summary

- Colloids -- Study nucleation, growth, morphology, and coarsening of crystal structures as well as rheological structural properties of:
  - binary alloys (highly ordered),
  - polymer mixtures,
  - fractal aggregates (highly disordered)

Key FIR - Experiment Interface Requirements

- Control of micro-gravity environment
- Data management



Compliance Summary: FCF design accommodates all PCS-2 interface requirements; Impact of G-jitter from within the FIR and from ARIS start-up under study; ARIS might not be required. Data management within the experimental timeline is TBD.

PHaSE-2 – Compliance Matrix

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
Hardware	Visual Images - Color (DIC, Phase contrast, Bright field, Dark field) FOV: 100 x 100µm to 2 x 2mm Resolution: ½ to 5 microns Frame Rate: 30fps	Analog Camera (FCF BSD B.2.3.5.3.1.2)	Leica Microscope	Yes – FCF camera with PI lens Yes
	Surveillance FOV: 15cm Resolution: Std. video Frame Rate: 30 fps		Toshiba Color Camera (FCF BSD B.2.3.5.3.1.2), Fish eye lens	Yes – Currently, LMM will build another FIR camera; FIR may take on this responsibility.

PHaSE-2 – Compliance Matrix – Continued

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
	Confocal Monochrome FOV: 100 x 100mm Resolution: 20nm Frame Rate: 30fps to several hundred fps	UHFR camera (FCF BSD B.2.3.5.3.1.3)	Leica Microscope	Yes Yes –FCF UHFR camera under evaluation; LMM has back-up if needed
	Processing: Centroid finding	IPSU(FCF BSD 5.2.5)	Analysis algorithm	Yes
	Tracking/Positioning: Focusing of the microscope	FSAP/IPSU (FCF BSD B.2.3.7, FCF BSD 5.2.5)	Focus algorithm	Yes – If timing is too long from FSAP to IPSU to control focusing, then LMM can purchase a DSP card for FSAP (duplicate the IPSU DSP)
	Trans-Illumination White light	Halogen White Light (FCF BSD B.2.3.5.4.1.1)		Yes – If FIR switches to a metal halide light then it would be used in place of the halogen.
	Confocal Light Source 532 nm Nd:YAG Laser	Nd:YAG Laser (FCF BSD B.2.3.5.4.1.2)		Yes
	Laser Tweezers 1064nm Nd:YAG Laser Power 1W		Nd:YAG Laser	Yes – Light will interface to a FIR GPI (FCF BSD B.2.3.3.3)

PHaSE-2 – Compliance Matrix – Continued

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
Experimental Environment (measurement and control)	Acceleration measurement	SAMS (FCF BSD 5.1.4)		Yes
	Acceleration control G/G_0: DC: 10^{-3} Jitter: TBD	ARIS (FCF BSD 5.3)		TBD – impact of jitter from ARIS start-up under study. ARIS might not be required
	Temperature: Internal to LMM	FSAP (A/D) (FCF BSD B.2.3.7)	TCs/Thermistor and signal conditioning	Yes – Data fed into FSAP A/D cards
	Pressure: Atmospheric (internal to the FIR)	Atmospheric Monitoring Assembly (FCF BSD B.2.3.10)		Yes
	Voltage: health & status	FSAP (A/D) (FCF BSD B.2.3.7)		Yes
	Air: Bulk heat removal – 330W	ATCS (FCF BSD 5.2.1)		Yes
	Vent to assist in clean-up	Vent Resource (FCF BSD 3.0)	Control valves	Yes

PHaSE-2 – Compliance Matrix – Continued

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
	Laser Tweezers control	FSAP (FCF BSD B.2.3.7)	LMM Avionics	Yes – Motor drives provided by FIR and LMM. Command signals from FSAP.
	Microscope Motors control	FSAP (FCF BSD B.2.3.7)	LMM Avionics	Yes – Motor drives provided by FIR and LMM. Command signals from FSAP.
Data	Total: 29,000 GB (w/o compression)	IOP (FCF BSD 5.2.4)		Yes – LMM will use a combination of on-board data processing, compression, data downlink, and IOP removable hard drives
	"Real time": Up/down link Post test: Yes	IOP/ISS HRDL (FCF BSD 3.0, 3.3, 5.2.4) Same		Yes Yes

PCS-2 – Compliance Matrix

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
Hardware	Visual Images - Color (DIC, Phase contrast, Bright field) FOV: 100 x 100µm to 2 x 2mm Resolution: ½ to 5 microns Frame Rate: 30fps	 Analog Camera (FCF BSD B.2.3.5.3.1.2)	Leica Microscope	Yes Yes
	Surveillance FOV: 15cm Resolution: Std. video Frame Rate: 30 fps		Toshiba Color Camera (FCF BSD B.2.3.5.3.1.2), Fish eye lens	Yes – Currently, LMM will build another FIR camera; FIR may take on this responsibility.
	Confocal Monochrome FOV: 100 x 100mm Resolution: 20nm Frame Rate: 30fps to several hundred fps	UHFR camera (FCF BSD B.2.3.5.3.1.3)	Leica Microscope	Yes Yes –FCF UHFR camera under evaluation; LMM has back-up if needed

PCS-2 – Compliance Matrix – Continued

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
	Spectrophotometer Dynamic range: 10000:1 S/N 16000/1 Full Scale S/N 1/1 at the low end		Leica Microscope Camera or Detector	Yes TBD – The FCF Hi Res camera (FCF BSD B.2.3.5.3.1.1) may suffice.
	Processing: Centroid finding Tracking/Positioning: Focusing of the microscope	ISPU (FCF BSD 5.2.5) FSAP/IPSU (FCF BSD B.2.3.7, FCF BSD 5.2.5)	Analysis algorithm Focus algorithm	Yes Yes – If the timing is too long from the FSAP to the IPSU to control the focusing, then LMM can purchase a DSP card for FSAP (duplicate the IPSU DSP)
	Trans-Illumination White light Power	Halogen White Light (FCF BSD B.2.3.5.4.1.1)		Yes – If FIR switches to a metal halide light, then it would be used in place of the halogen.
	Confocal Light Source 532 nm Nd:YAG Laser	Nd:YAG Laser (FCF BSD B.2.3.5.4.1.2)		Yes
	Laser Tweezers 1064nm Nd:YAG Laser Power 1W		Nd:YAG Laser	Yes – Light will interface to a FIR GPI (FCF BSD B.2.3.3.3)

PCS-2 – Compliance Matrix – Continued

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
	Spectrophotometer Light Source 400-700nm monochromatic white light		TBD	TBD – LMM is looking at options including the FIR white light.
Experimental Environment (measurement and control)	Acceleration measurement	SAMS (FCF BSD 5.1.4)		Yes
	Acceleration control G/G_0: DC: 10^{-3} Jitter: TBD	ARIS (FCF BSD 5.3)		TBD – impact of jitter from ARIS start-up under study. ARIS might not be required
	Temperature: Internal to LMM Pressure: Atmospheric (internal to the FIR) Voltage: Detector intensity, health & status	FSAP (A/D) (FCF BSD B.2.3.7) Atmospheric Monitoring Assembly (FCF BSD B.2.3.10) FSAP (A/D) (FCF BSD B.2.3.7)	TCs/Thermistor and signal conditioning	Yes – Data is fed into FSAP A/D cards Yes Yes

PCS-2 – Compliance Matrix – Continued

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
	Laser Tweezer control	FSAP (FCF BSD B.2.3.7)	LMM Avionics	Yes – Motor control cards are provided by both FIR and LMM. Command signals come from the FSAP.
	Microscope Motors control	FSAP (FCF BSD B.2.3.7)	LMM Avionics	Yes – Motor control cards are provided by both FIR and LMM. Command signals come from the FSAP.
	Air: Bulk heat removal – 330W	ATCS (FCF BSD 5.2.1)		Yes
	Vent to assist in clean up	Vent Resource (FCF BSD 3.0)	Control valves	Yes
Data	Total: 58,200 GB (w/o compression	IOP (FCF BSD 5.2.4)		Yes – LMM will use a combination of compression, data downlink and the IOP removable hard drives to manage the data.
	"Real time": Yes Post test: Yes	IOP/ISS HRDL (FCF BSD 3.0, 3.3, 5.2.4) Same		Yes Yes

PHaSE-2, PCS2 – Critical Hardware Summary

FCF Provided	PI Provided
• FSAP* • Analog Camera • UHFR Camera • White Light Source • Nd:YAG 532nm Laser • IPSU* • SAMS FF Head • AMA • ARIS**	• Microscope/Mini-Facility • Analog Camera • Laser Tweezers (1064nm Laser) • Spectrophotometer • Microscope Avionics Package

*Includes embedded software

**Use of ARIS dependant on μg disturbance levels

PHaSE-2, PCS2 – Mass and Stowage Estimates

Item	Component Stowage Volume (cm^3)	Mass (Kg)	# Utilized	# in Rack	# in Stowage
FSAP Main Section[1]			1	1	
PI FSAP	12,455	12.4	0	0	1
IPSUs[1]			1	2	
DCMs	4,341	3.3	0	0	4
Color Analog Controller	3,174	1.5	1	1	0
Color Analog Camera Head	48		1	1	0
Monochrome Digital IAM	1,515	0.9	0	0	2
UHFR Camera	1,674	2.0	1	1	0
Color Macro OM	1,429	1.5	0	0	1
Monochrome Macro OM	3,089	1.3	0	0	2
High Magnification OM	5,593	1.8	0	0	1
Dual White Light Source[1]			1	1	
White Light Panel (with bundle)	9,391	2.4	0	0	1
Nd:YAG Laser[1]			1	1	
Dual Laser Diode[1]			0	1	
25mm Collimator	270	0.2	0	0	1
50mm Collimator	917	0.8	0	0	1
Gimbaled Mirror	4,508	4.7	0	0	1
Translation Stage	1,980	5.2	0	0	1
Movable Mount	6,415	4.2	0	0	2
AMA			1	1	
SAMS FF Head	386	1.2	1	1	0

LMM - Core	325,000	83.0	1	1	0
LMM - ETMs	9,396	4.0	1	1	0
LMM - IOP Hard Drives[3]			2	2	TBD
LMM - Monochrome Camera[2]			0	0	0
LMM - Color Camera[2]			1	1	0
LMM - Laser Tweezers[2]			1	1	0
LMM - Spectrophometer[2]			1	1	0

Mass

- Rack Operational: 752.7Kg

Volume

- Stowage Operational[4]: $0.099m^3$ + HD Stowage
- LMM Total Stowage[4]: $0.423m^3$ + HD Stowage

1 - Component is stored on back of bench (as standard interface)

2 - Mass and volumes are part of core mass and volumes

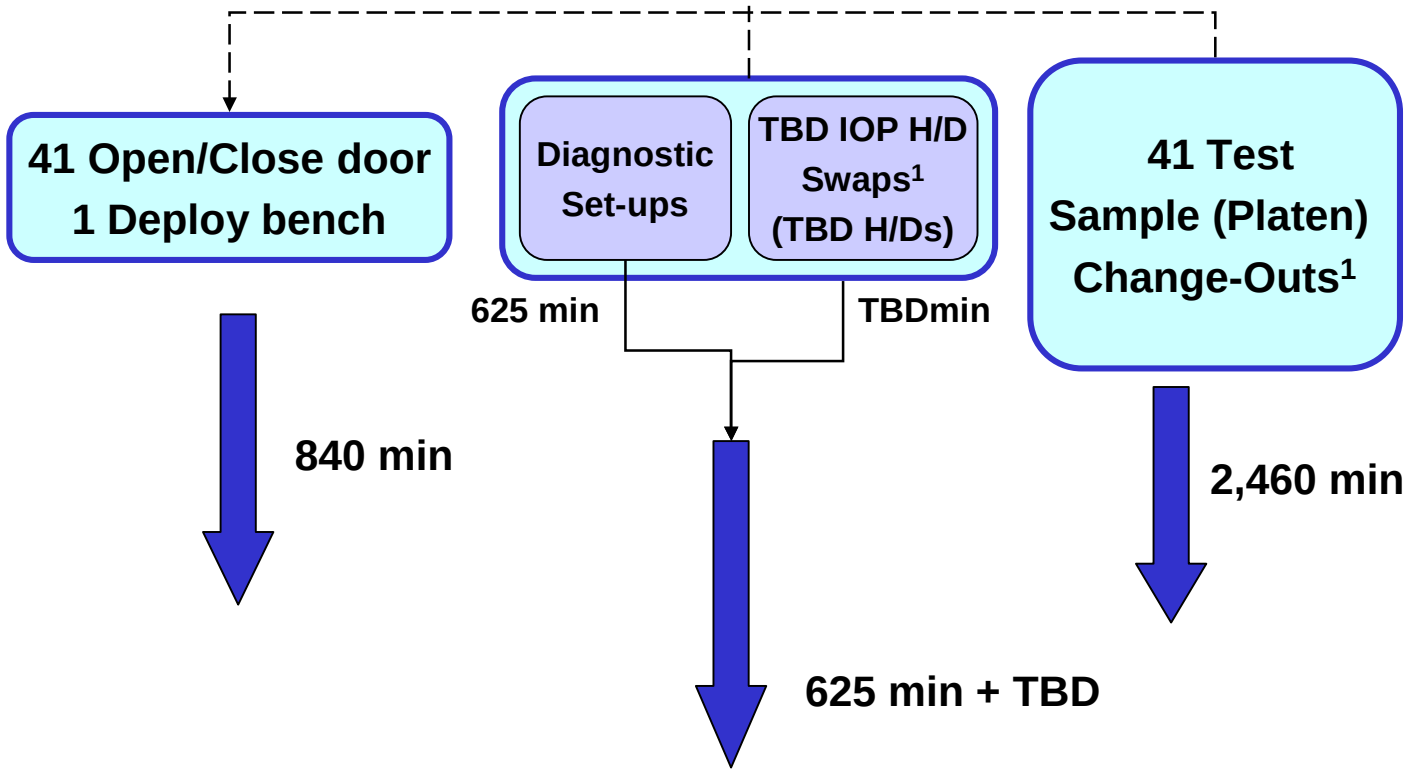
4 - Include 30% stowage material factor

PHaSE-2, PCS2 – Operational Power Profile and ECS Load Profile

Operational Power Profile & ECS Load Profile -- TBD

- Data management within the timeline drives power & energy requirements (i.e. downlink, storage, on-board processing [10,000:1 reduction] and compression)
  - Total raw imaging data = 87,243 GB
  - Example data management scenario:
    - 10% of raw images down linked
    - 30% of raw images stored on hard drives @ 70 GB/hard drive
    - 100% of raw images post processed & down linked
    - Downlink time = 5,520 hrs (230 days)
    - Hard drives required = 374 !!! (186 hard drive swaps)
- Energy (excluding data downlink) = 3,443 kW-hrs
- Operational Hours: 3,130
- Average Power: ~1,100W

PHaSE-2, PCS2 – Crew Time



Total Crew Time
3,925 +TBD minutes (i.e. 65.4 + TBD hrs)

1 – HD Swaps and platen changes coordinated

Rapidly Sheared Bubble Suspension (MOBI)

Basis Experiment Science Summary

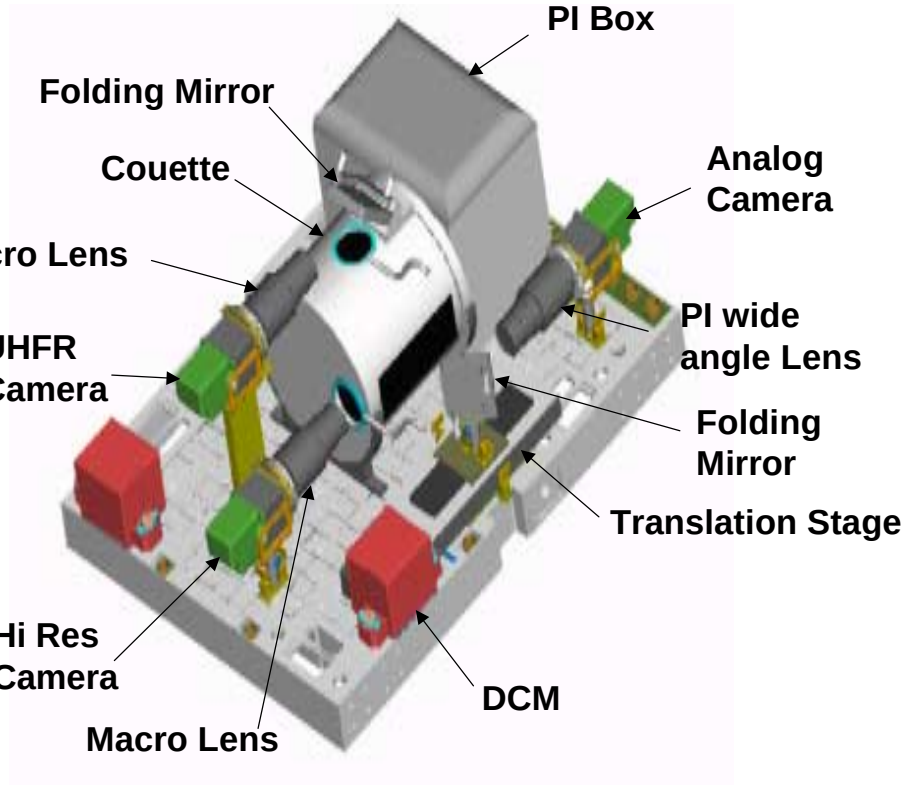
- PI: Ashok Sangani (Syracuse)
- PM: Monica Hoffmann (GRC)

Experiment Summary

- Study the radial bubble profile in a cylindrical Couette device over various shear rates, volume fractions, and bubble diameters.
- Study the dependence of bubble pressure and viscosity on shear rate and bubble volume fraction and radius.

Key FIR - Experiment Interface Requirements

- Experimental package
- Control of micro-gravity environment



Compliance Summary: FCF design accommodates all MOBI interface requirements, however, design of PI test cell to reduce mass and minimize vibration is a significant engineering challenge.

MOBI – Compliance Summary

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
Hardware	Imaging Bubbles:	Hi Res Camera Macro Lens		Yes Yes
	Imaging Thru Inner Wall:	UHFR Camera Macro Lens		Yes Yes
	Surveillance:	Analog Camera	Wide Angle Lens	Yes Yes
	On-orbit Processing	IPSU		Yes – if required
	Tracking/Positioning: remote positioning of camera required	FSAP	Translation Device	Yes -- Required to re-position bubbler camera between tests
	Illumination: Bubbles/Bubbler Inner Wall Surveillance	Halogen White Light (2), Light Panel & Fiber Bundle	Light Source for Overall Surveillance View	Yes – If FIR switches to a metal halide light then it would be used in place of the halogen Yes

MOBI – Compliance Summary – Continued

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
Experimental Environment (measurement and control)	Acceleration control G/G_0: DC: 10^{-3} g Jitter: Sensitive to frequencies in TBD range	SAMS ARIS	May require PI specific H/W to isolate disturbances generated by EP	Yes Yes TBD
	T measurement & control P measurement & control Other functions: chamber rotation; bubbler position; probe motor; camera trans	ATCS, FSAP FSAP FSAP	H/W & S/W H/W & S/W Control software	Yes Yes Yes
	GN2: ISS nitrogen for generating test chamber bubbles & controlling P	Gas Interface Panel	Lines, QD's, control valves, and controllers	Yes
Data	13.7 GB per run; 659 GB total image data Post test: (TBD) down linked to assess whether to proceed	IOP IOP/ISS HRDL		Yes -- data management required Yes -- A sampling of data from each run to be down linked prior to proceeding to next run
Resources	Mass: TBD		Typical PI allocation is about 65 kg.	TBD -- Experiment is heavy; Test cell with fluid is about 68 kg.
	PI Power: Requirement estimated at 300 to 500 W Energy -- TBD	FIR Electrical Power	Exp Duration ~ 2 min/test X 48 tests + set up between test	Yes. Probably below 500 W. TBD

Foam Optics and Mechanics (FOAM)

Basis Experiment Science Summary

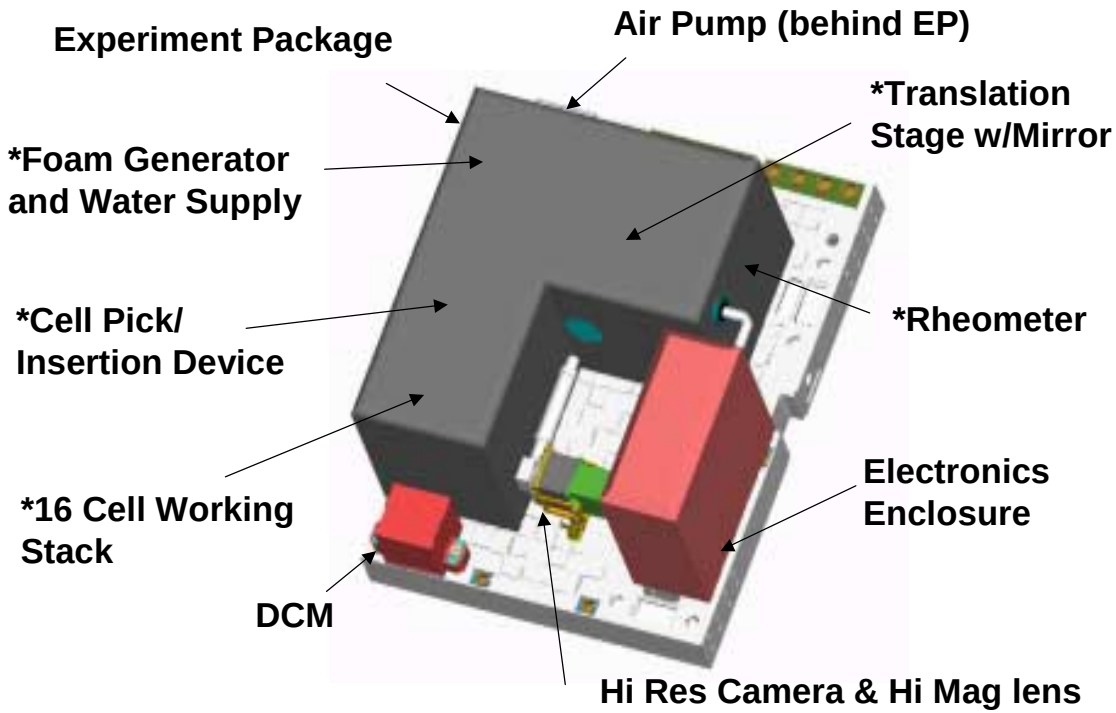
- PI: Doug Durian (UCLA)
- PM: Joe Balombin (GRC)

Experiment Summary

- Study the microscopic structures and dynamics of foams and the way foam melts into a simple liquid as a function of varying liquid content percentages and shear strain rates.

Key FIR - Experiment Interface Requirements

- Experimental package mass & volume
- Control of micro-gravity environment
- Data management



*Denotes approximate component location inside EP

Compliance Summary: FCF design accommodates all FOAM interface requirements, however, redesign of the PI rheometer to reduce its mass and size and minimize vibration is a significant engineering challenge. Data management within the experimental timeline is TBD.

FOAM – Compliance Summary

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
Hardware	Imaging Foam	Hi Res Camera Hi Mag lens		Yes Yes
	Imaging Filling Ops	Analog Camera Macro lens	Wide angle lens if required FOV >10 cm	Yes
	Tracking/Positioning	IPSU, FSAP	Translation device with +/- 2.5 cm capability	Yes – Translation required to maintain bubbles in FOV
	Back-lighting for microscopic view.	White Light Sources		Yes –FCF bundled sources or light panels
	Laser required for other diagnostics	Nd:YAG laser		Yes
Experimental Environment (measurement and control)	Acceleration Measure Acceleration control G/G_0: DC: < 0.01 Jitter: TBD	SAMS ARIS	May require PI H/W to isolate EP-generated disturbances	Yes Yes
	Temperature measurement	FSAP	Sensors and controllers	Yes
	Pressure measurement	FSAP	Sensors and controllers	Yes
	Voltage (light scattering data): APD outputs to correlator cards	FSAP(volts or RS-422)	APDs and cards	Yes – RS-422 at bench front

FOAM – Compliance Summary – Continued

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
	rheological measurements	FSAP	Rheometer	Yes
	P, T, & humidity control	FSAP	Sensor hardware, software, and valves	Yes
	Translation control required	FSAP	Translation hardware	Yes
	Air: Requires stable temperatures for the foam as noted above.	ATCU	More specific thermal conditioning is required	Yes
	Water: May help to establish desired thermal conditions prior to or during testing.	Lines and QDs if used.	Lines, QDs, and HX.	Yes
	GN2: ISS nitrogen may be used for generating foams.	Gas Interface Panel	Lines, QDs, and controllers	Yes – Assuming the ISS gas is supplied at 5 kg/hr (about 17 liters / min @ 60 psia).
	Components Req. Venting/ Vacuum: TBD whether this resource may be used to facilitate suspensions changeout; and/or to control pressure	Vent Resource	Control Valves	Yes – Also may be useful in facilitating the pressure maintaining functions required by the experiment.

FOAM – Compliance Summary – Continued

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
Data	12 min per test run 48 test cells total 23.4 GB per sample cell 1.12 TB total (48 cells)	IOP		Yes –assumes combination of data down link, compression, on-board processing,storage.
	"Real time": required for cell filling. Post test: data (TBD) down linked to assess whether to proceed to next experiment.	IOP/ISS HRDL		Yes – A sampling of data from each run to be down linked prior to proceeding to next run
Resources	Power Req's: TBD depends upon engineering design		Typical PI allocation is about 500 W, which should be sufficient.	Yes
	Bench Volume: rotating cone and plate device with diameter of 10 to 20 cm and about 2 cm height; rheometer adds additional significant TBD volume and mass	Volume on front side of optics bench	PI-specific components other than chamber to be determined (e.g., rheometer).	TBD. Engineering challenge to repackage rheometer to fit on bench.

GFM – Granular Flow Medium

- *μgSEG ≡ Microgravity Segregation in Collisional Shearing Flows of Binary Mixtures of Inelastic Spheres*

- *SiGMA ≡ Studies of Gas-Particle Interactions in Microgravity Flow Cell*

GFM – Microgravity Segregation in Collisional Shearing Flows of Binary Mixtures of Inelastic Spheres (μgSEG)

Basis Experiment Science Summary

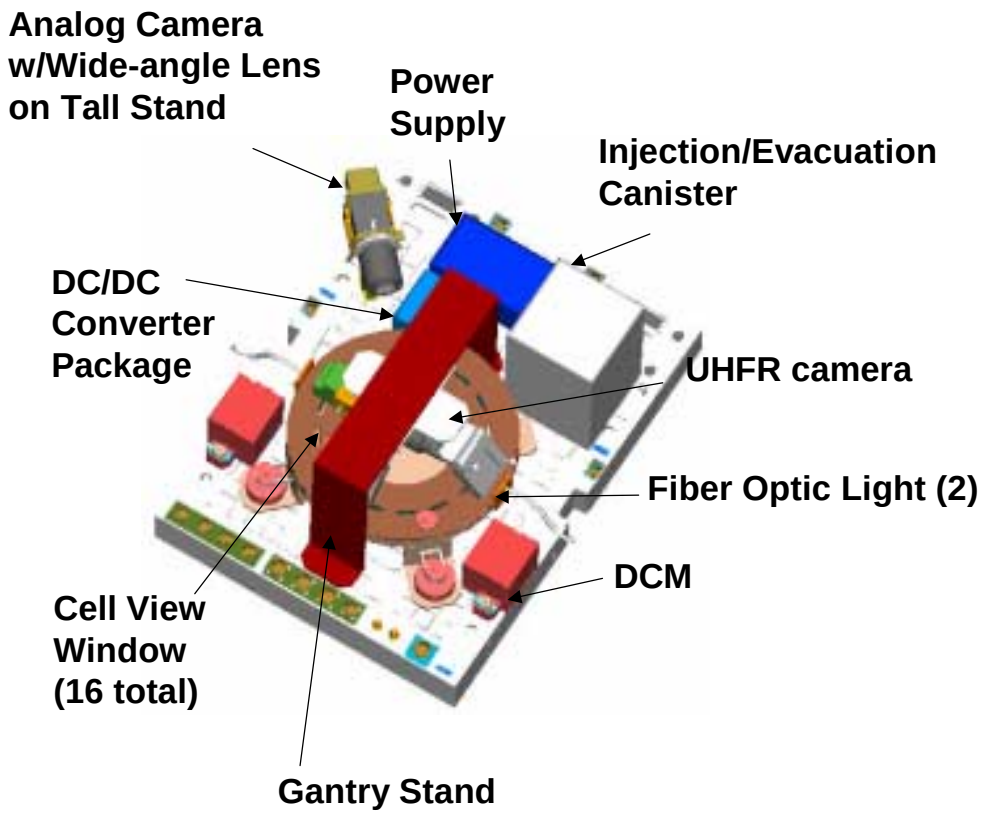
- PI: James Jenkins (Cornell)
- PM: John Caruso (GRC)

Experiment Summary

- Study particle segregation in collisional flows of binary (dry granular) sphere mixtures. The cell has a moving inner boundary and a fixed outer boundary that imparts the shearing motion to the flow.

Key FIR - Experiment Interface Requirements

- Control of micro-gravity environment



Compliance Summary: FCF design accommodates all *μgSEG* interface requirements.

GFM -- Studies of Gas-Particle Interactions in Microgravity Flow Cell (SiGMA)

Basis Experiment Science Summary

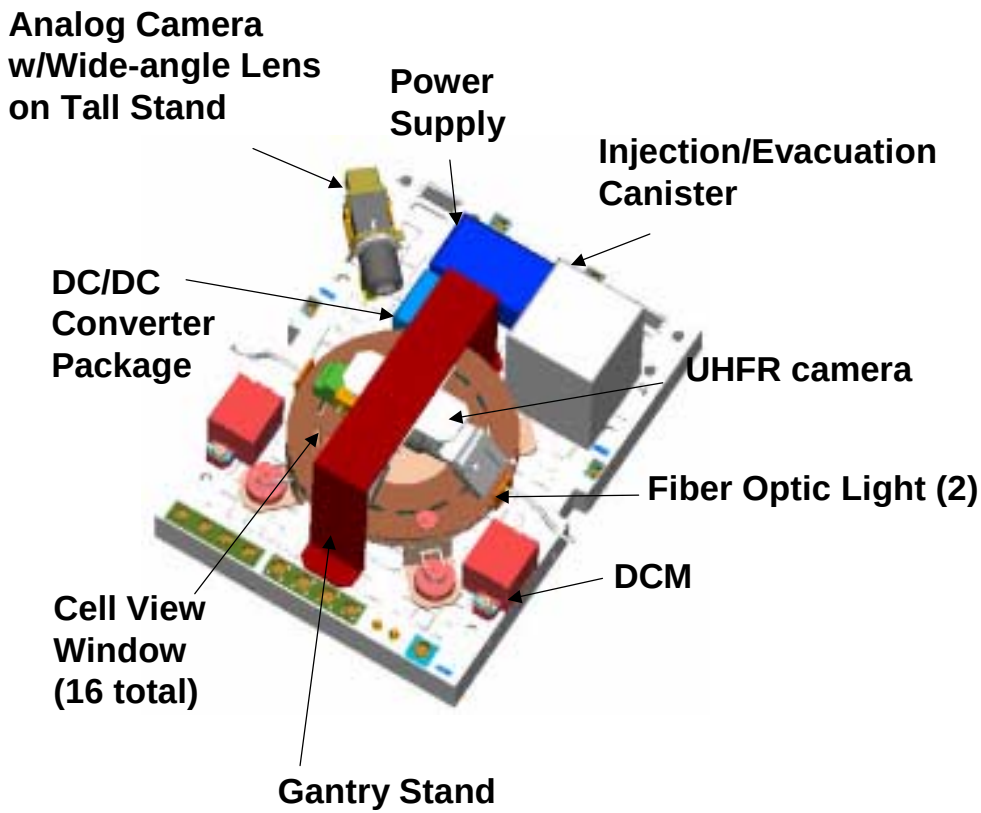
- PI: Michelle Louge (Cornell)
- PM: John Caruso (GRC)

Experiment Summary

- Study the interaction between a flowing gas with relatively massive particles (constant diameter spheres) that collide with each other and with the moving boundaries of the cell.
- The cell (Jenkins experiment cell) is racktrack-shape design. Co-current and counter-current gas flows will be introduced through four independent distributors.

Key FIR - Experiment Interface Requirements

- Control of micro-gravity environment
- Data management



Compliance Summary: FCF design accommodates all SiGMA interface requirements except the requirement for $G/G_0 < 10^{-7}$ for 1 of 90 data points. Data management within the experimental timeline is TBD.

GFM (SiGMA and μgSEG) – Compliance Matrix

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
Hardware	Surveillance of moving cell components FOV: 60 x 60cm Resolution: Std. Video Frame Rate: 30fps	Analog Camera (FCF BSD B.2.3.5.3.1.2), Quick-disconnect lens mount (FCF BSD B.2.3.5.3.1.5)	Lens, camera mounting	Yes
	Images of moving sphere/particles FOV: 25 x 25mm Resolution: 512x384 Frame Rate: 470 fps Exposure: TBD Number of frames: up to 10,000 frames	Macro Lens (FCF BSD B.2.3.5.3.1.5) UHFR Camera (FCF BSD B.2.3.5.31.3)	Beam splitter, polarizer, etc	Yes Yes – depending on the total memory in the UHFR - it may not be possible to record all 10,000 frames at once but rather take the images in 5000 frame chunks.
	Process and analyze images	IPSU (FCF BSD 5.2.5)	Software	Yes
	Position optics in correct locations relative to cell windows	FSAP (FCF BSD B.2.3.7) /DCM (FCF BSD 5.2.6) FIR stepper motor controllers	Stepper motors; software	Yes
	Light source for particle fluorescence; Wave length: 532nm	Nd:YAG Laser (FCF BSD B.2.3.5.4.1.2)		Yes

GFM (SiGMA and μgSEG) – Compliance Matrix – Continued

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
	Sufficient light for sphere tracking: White light	White light source (FCF BSD B.2.3.5.4.1.1)	Ring light; any additional filters	Yes
	Lighting for surveillance: White light		White Light	Yes – May be able to use 2nd bulb in the FIR white light if it is not required for the sphere tracking.
Experimental Environment (measurement and control)	Acceleration measure Acc. control G/G_0: μgSEG: DC<0.4 RMS<5.8×10^{-4}	SAMS (FCF BSD 5.1.4) ARIS (FCF BSD 5.3)		Yes Yes
	Acceleration control G/G_0: SiGMA: DC < 10^{-6} RMS<2.5×10^{-5} DC<10^{-7} (1 test pt.)	ARIS (FCF BSD 5.3)		Yes No – ISS does not provide this level of micro g.

GFM (SiGMA and μgSEG) – Compliance Matrix – Continued

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
	Measure air temperature in cell: 1 temp./2Hz	Data is fed into FSAP A/D cards (FCF BSD B.2.3.7)	TCs, signal conditioning	Yes
	Measure pressure in cell: 1 Abs./2 Hz TBD Diff./2 Hz	Same	Absolute and differential pressure transducers & S/W	Yes
	Measure mass flow through cell	Same	Mass flow sensor/ controller, software	Yes
	Measure strain along cell walls	Same	Strain gages, signal conditioning, S/W	Yes
	Provide experiment health to ISS	Same	Sensors and S/W	Yes
	Control shear cell motors	FSAP (FCF BSD B.2.3.7). Command signals	Avionics, motor controllers	Yes
	Locate cameras and optics in proper relation to shear cell	FSAP or DCM (FCF BSD 5.2.6) motor controllers		Yes
	Control gas flow	Control signals from the FSAP	Mass flow controller, flow regulators and valves; software	Yes

GFM (SiGMA and μgSEG) – Compliance Matrix – Continued

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
	Maintain experiment equipment at suitable temperature: Air: 500 W Water: 700 W	ATCS (FCF BSD 5.2.1) Post mounted fan	Possibly use additional fans to cool blocked area and hot spots Isolation valves and instrumentation	Yes – FCF does provide post mounted fans. Yes – Use of cold plates or water jackets to cool HW.
	Structurally isolate rotating cell and motors		GFM structure	Yes
	Gas flow in cell: GN2 Particle injection and removal	Gas Interface Panel (FCF BSD B.2.3.9) Same	Gas distribution system, regulators System for inserting & removing spheres	Yes Yes
	Vacuum to pull down shear cell: (.1 to .01 ATM) Vacuum to enable specific gas flows through cell:	Vent Resource (FCF BSD 3.0) Same	Control valves and regulators; software Same	Yes Yes
	Spheres with proper material, surface properties and size		GFM	Yes

GFM (SiGMA and μgSEG) – Compliance Matrix – Continued

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
	Power conditioning and conversion	FIR voltage conversion	Power conditioning, breakers	Yes
	Trouble-shoot experiment operation, format data:		Software	Yes
	Provide axisymmetric cell to shear and/or to produce required flow conditions		GFM	Yes
Data	Store data prior to transmitting to PI: Max per point: UHFR Camera: 2.6GB Analog Camera: 2.7GB	IOP (FCF BSD 5.2.4)		Yes -- Data numbers do not reflect possible compression or reduction. Numbers assume all 512x512 pixels are used yet this isn't required.
	Total image data: μgSEG: 21 GB	IOP (FCF BSD 5.2.4)		Yes
	Total image data: SiGMA: 1,576 GB	IOP (FCF BSD 5.2.4)	Any additional GFM storage if needed; 22 hard drives at 70 GB (available) per hard drive	Yes – GFM will make use of data compression, the available down link and the IOP removable hard drives.

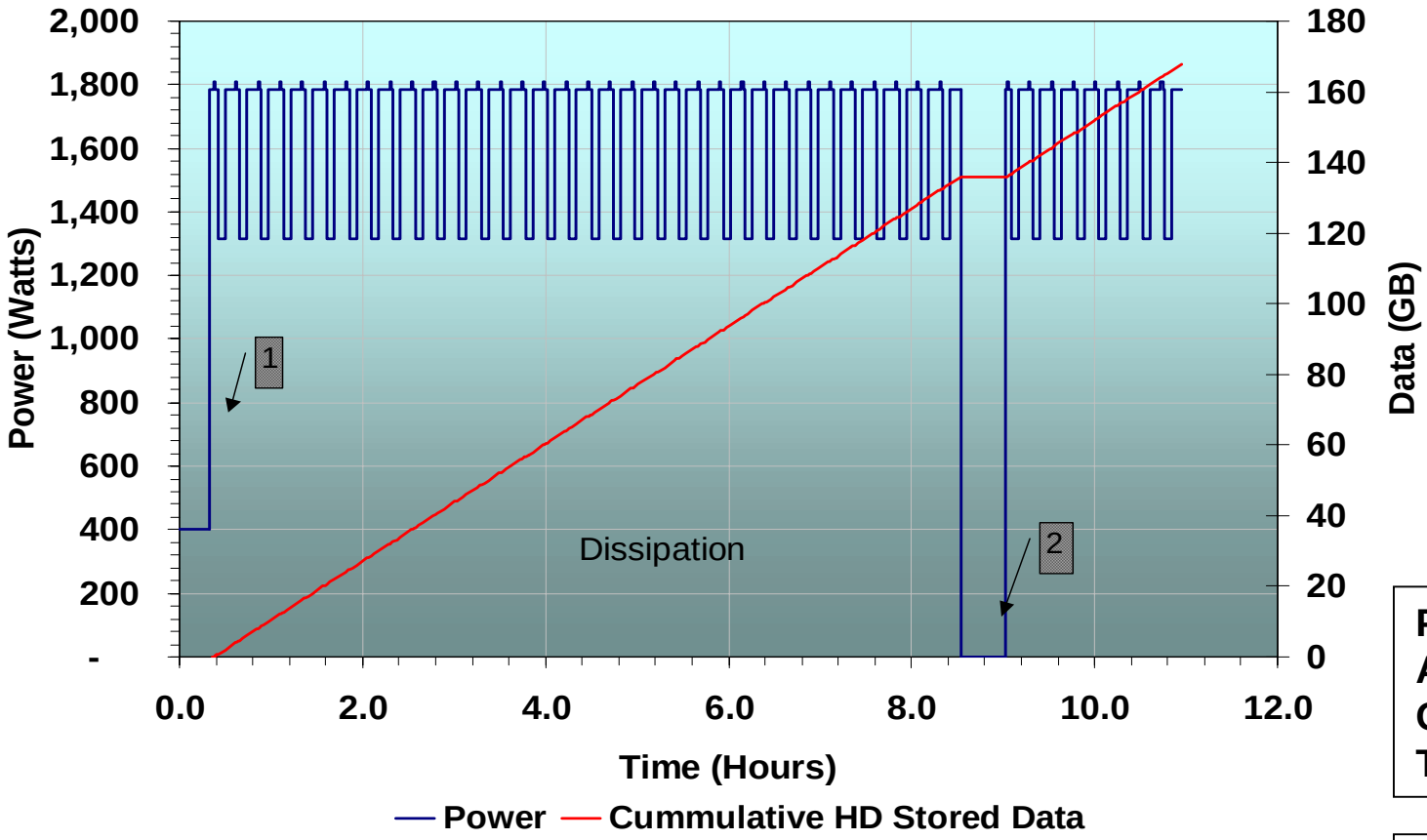
GFM (SiGMA and μgSEG) – Compliance Matrix – Continued

System	Key Requirements	FCF Hardware	PI Hardware	Compliance
	Provide control and data to experiment PI/ground operators:			
	Uplink: sequence experiment and control operations	IOP (FCF BSD 3.0, 3.3, 5.2.4)	Software on board and at TSC	Yes
	Downlink: Perhaps 100 images/run will be needed, along with some calculated statistics	IOP/ISS HRDL (FCF BSD sect. 3.0, 3.3, 5.2.4)	Software on board and at TSC	Yes

GFM - μgSEG & SiGMA – Critical Hardware Summary

FCF Provided	PI Provided
• FSAP • PI FSAP* • Analog Camera • UHFR Camera • White Light Source • Nd:YAG 532nm Laser • DCMs • IPSU* • SAMS FF Head • AMA • ARIS *** Includes embedded software**	• Mini-Facility

GFM - μgSEG & SiGMA – Operational Power Profile



Shown here is the viscous dissipation segment of SiGMA. After 35 test points, change-out of the IOP hard drives is required.

1- Diagnostics Power-up
2- HD Swaps

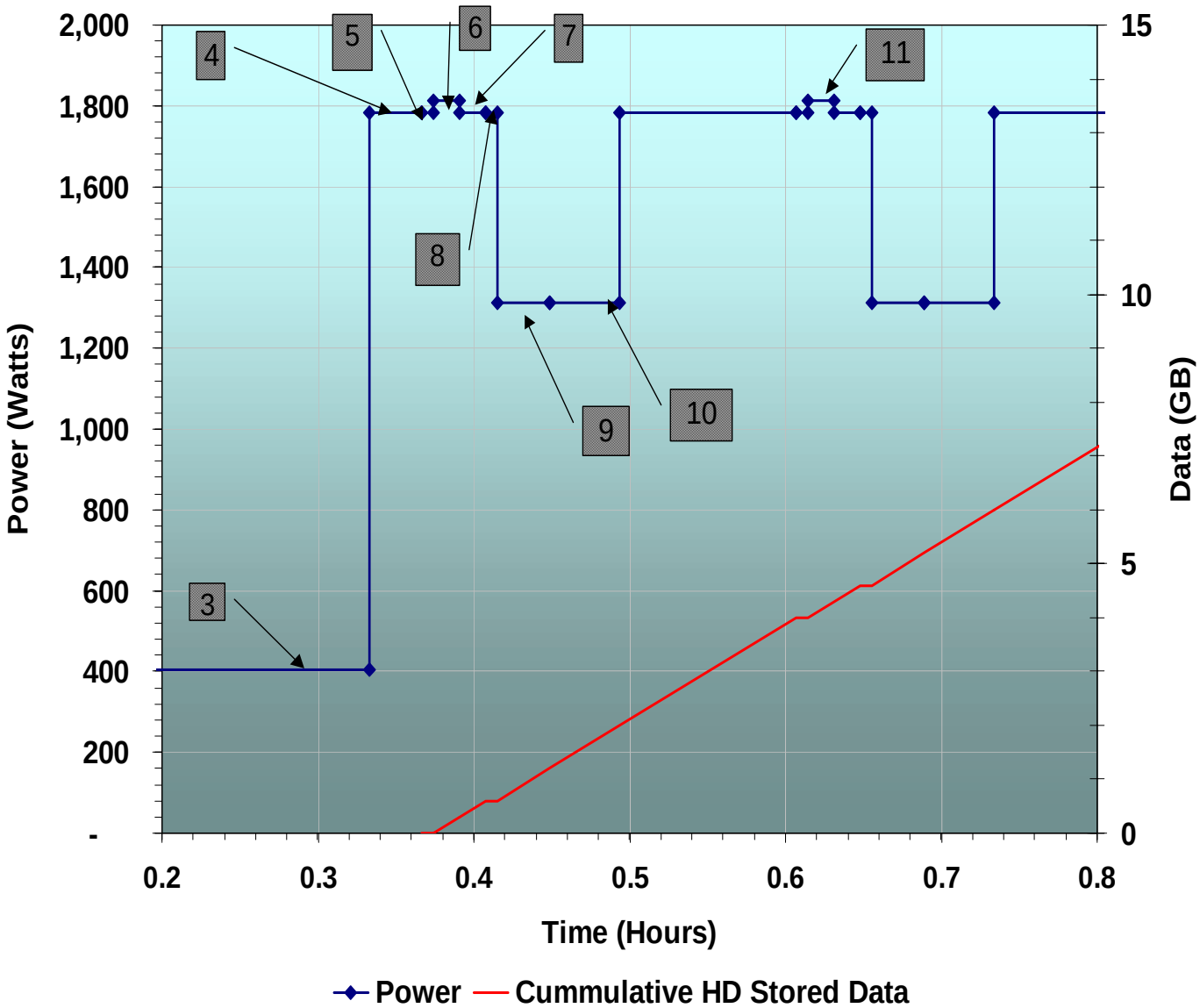
Peak Power = 1,896 W
Average Power = 964 W
Operational hrs = 113
Total Energy = 109.7 kW-h

Peak ATCU Load = 1,618 W
Peak WTCS Load = 277 W

Assumptions:

- 1,580 GB of image data generated by GFM
- All data stored on 22 hard drives (11 IOP HD pairs)
- % of down linked TBD; power profile, operation hours, total energy do not include downlink
- SiGMA test runs: 42 for Dissipation (2 pts/run); 158 for Drag I (2 pts/run); 24 for Drag II (16 pts/run)
- mgSEG test runs: 4 data points

GFM - μgSEG & SiGMA – Operational Power Profile – Continued



3 - Diagnostics Power-up

4 - Equilibration

5 - Data Collection

6 - Move Camera, UHFR Data to IPSU

7 - Finish UHFR Data to IPSU

8 - Data Collection

9,10 - Data from UHFR to IPSU, FSAP to IOP (White Light Off)

11 - Data from IPSU to IOP and next data point equilibration

GFM - μgSEG & SiGMA – Mass and Stowage Estimates

Item	Component Stowage Volume (cm^3)	Mass (Kg)	# Utilized	# in Rack	# in Stowage
FSAP Main Section[1]			1	1	
PI FSAP	12455	12.4	1	1	0
IPSUs[1]			1	2	
DCMs	4341	3.3	3	2	2
Color Analog Controller	3174	1.5	1	1	0
Color Analog Camera Head	48		1	1	0
Monochrome Digital IAM	1515	0.9	0	0	2
UHFR Camera	1674	2.0	1	1	0
Color Macro OM	1429	1.5	0	1	0
Monochrome Macro OM	3089	1.3	1	1	1
High Magnification OM	5593	1.8	0	0	1
Dual White Light Source[1]			1	1	
White Light Panel (with bundle)	9391	2.4	0	0	1
Nd:YAG Laser[1]			1	1	
Dual Laser Diode[1]			0	1	
25mm Collimator	270	0.2	0	0	1
50mm Collimator	917	0.8	0	0	1
Gimbaled Mirror	4508	4.7	0	0	1
Translation Stage	1980	5.2	0	0	1
Movable Mount	6415	4.2	0	0	2
AMA			1	1	
SAMS FF Head	386	1.2	1	1	0

GFM - Core	TBD	82.0	1	1	0
GFM - IOP Hard Drives (TBD)	962		2	2	20

Mass

- Rack Operational: 771.5 Kg

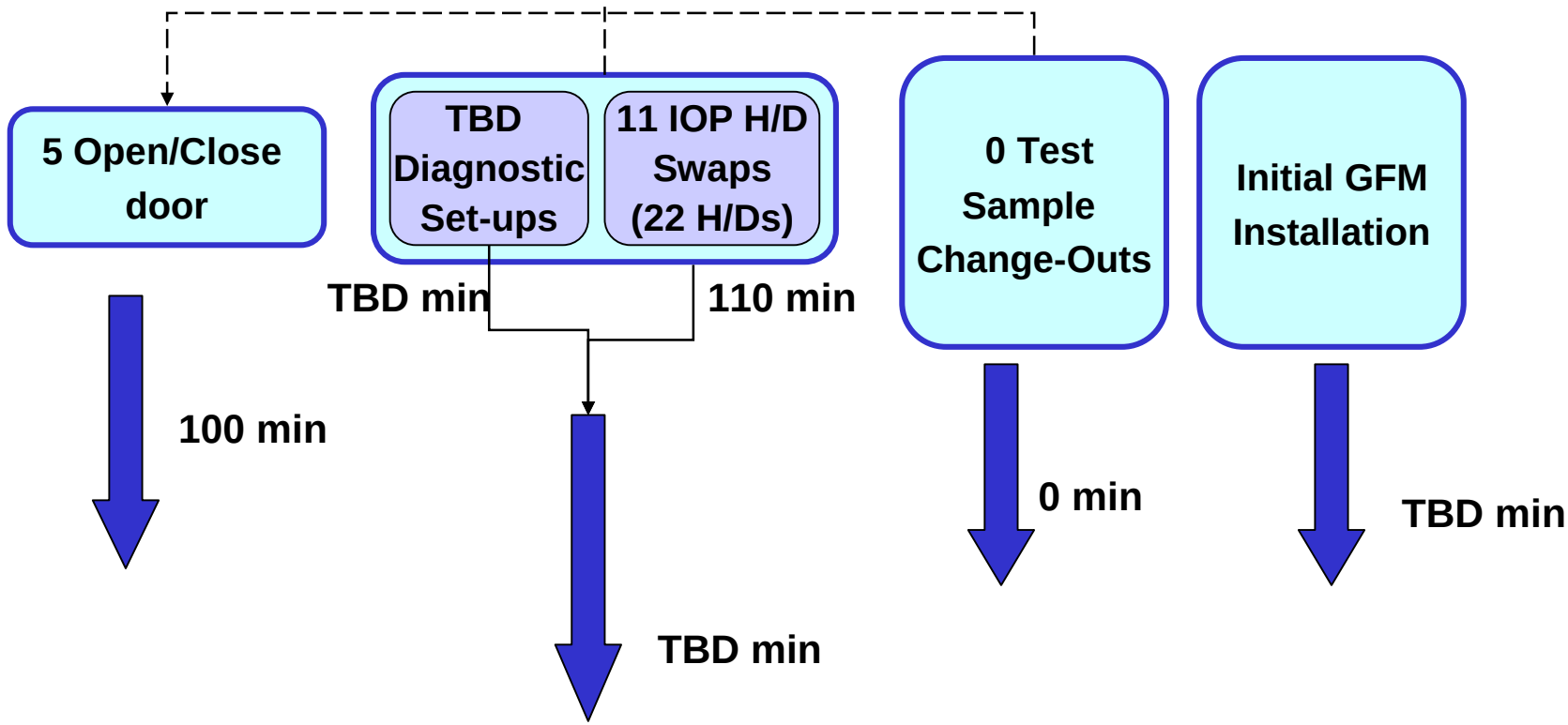
Volume

- Stowage Operational[2]: $0.073m^3$ + HD stowage

1 - Component is stored on back of bench (as standard interface)

2 - Include 30% stowage material factor

GFM - μgSEG & SiGMA – Crew Time



Total Crew Time

210 + TBD Mins (i.e. 3.5 + TBD hours)

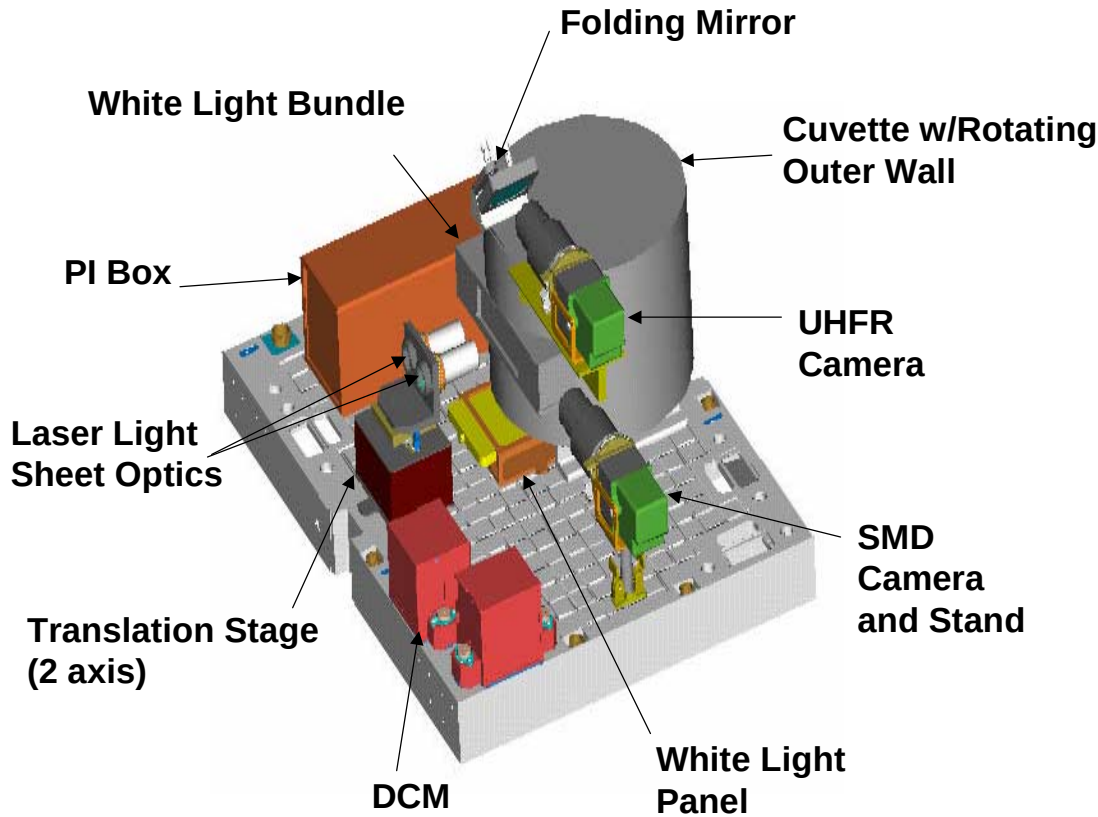
Basis Experiment f13A – Multiphase Flow Boiling

Basis Experiment Science Summary

- PI: McQuillen/Balakotaiah
- PM:M. Hickman (GRC)

Experiment Summary

- Study of multiphase flow in a conduit with no heat transfer. One of the basic requirements is flow that is stable and can run through a STRAIGHT line test section with a length-to-diameter ratio of at least 100.



Key FIR - Experiment Interface Requirements

- Experimental package dimension

Compliance Summary: FCF design does NOT with SRED requirements for f13A. Straight line section with length/diameter ratio >100 will not fit in the available bench volume; alternative designs do not meet this science requirement.

Basis Experiment f13A – Compliance Summary

System	Key Requirement	FCF H/W	PI H/W	Compliance
Hardware	Surveillance Contact line Film thickness Temperature fields Velocity fields	Hi Res camera UHFR camera Nd:YAG laser Macro lens (2) White light & panel	Light sheet optics	Yes
Experimental Environment (measurement and control)	Acceleration measurement: Acceleration control G/G_0: DC: $<10^{-4}$ Jitter: "isolation" < 10 HZ	SAMS ARIS		Yes Yes
	Temp: 36 measurements; -15<T<200 °C +/- 0.5 °C Pressure: 1 measurement 1 < P < 10 atm +/-5%	ATCU, FSAP		Yes
Data	47,560 GB total image data (450 tests @ 2 to 10 min per test)	IOP, IPSU	Extra data storage, compression and/or on-board processing	Yes
Resources	Avg Power: 2,158			Yes -- management of power required
Resources	Bench volume		Experimental package design does NOT fit on the bench	No

Mechanistic Study of Nucleate Boiling Heat Transfer [for f13B]

Basis Experiment Science Summary

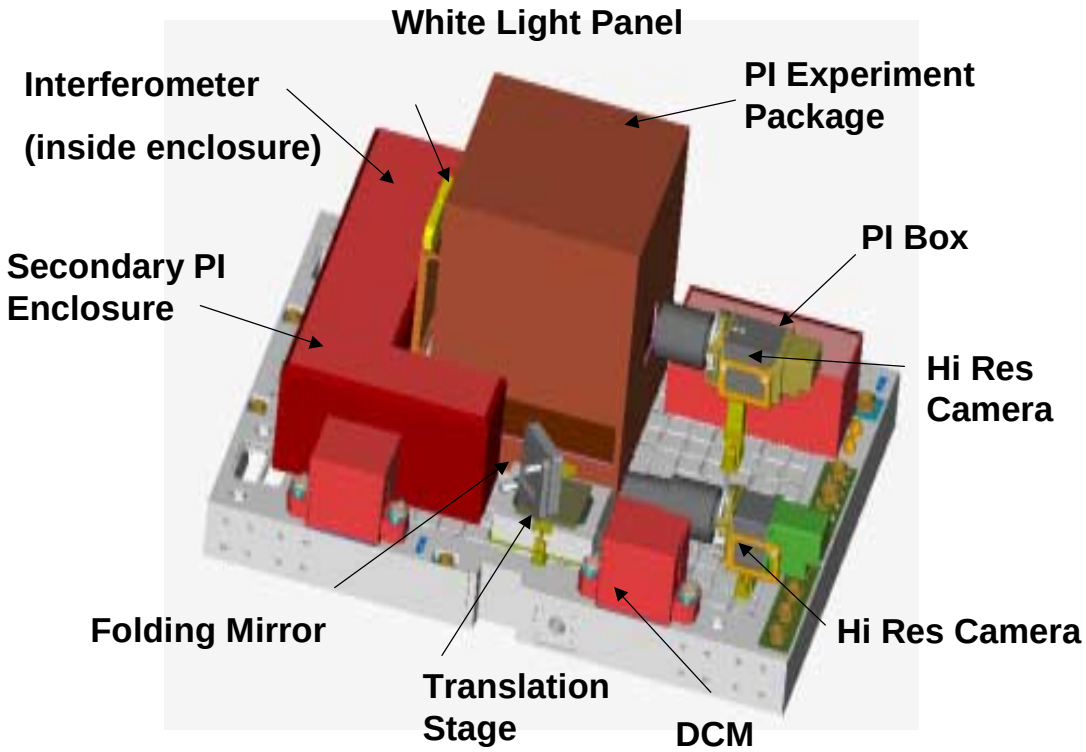
- PI: Vijay Dhir (UCLA)
- PM: Kirk Logsdon (GRC)

Experiment Summary

- Study bubble nucleation, growth and departure; bubble merger and interactions; microlayer evaporation and condensation and the effects of recoil pressure due to phase change and liquid inertia.

Key FIR - Experiment Interface Requirements

- Mass and volume of experimental package
- Data management
- Multiplexing multiple thermocouples



Compliance Summary: FCF design accommodates all interface requirements, however, design of PI test cell to reduce mass and volume is a significant engineering challenge.

Mechanistic Study of Nucleate Boiling Heat Transfer – Compliance Summary

System	Key Requirement	FCF H/W	PI H/W	Compliance
Hardware	•Nucleation/Growth (full bubble) •Contact Line •Tracking/Positioning •Light source for bubble imaging •Interferometry	•Hi Res camera & macro lens •Hi Res camera & macro lens •White light & panel •Nd:YAG laser	•Wide angle lens •Tracking device	Yes TBD – large FOV for contact line Yes Yes Yes
Experimental Environment (measurement and control)	Acceleration measurement Acceleration control G/G_0: DC: $<2X10^{-4}$ aligned; know direction of G-vector Jitter: avoid amplitudes of this range for freq. < 10 Hz	SAMS ARIS		Yes Yes – ARIS; PI to orient EP
	Temp: 36 measurements; 65<T<124° C +/- 0.1 °C	FSAP	Sensor hardware, Signal conditioning, & S/W	Yes – large number of TC's; multiplexing may be needed
	Press: 110<P<150 kPa +/- 0.5	FSAP	Transducer H/W & S/W	Yes
	GN2 and vent/vacuum may be used to control chamber pressure	Gas Interface Panel Vent resources	Lines, valves, QD's Control valves	Yes

Mechanistic Study of Nucleate Boiling Heat Transfer – Compliance Summary – Continued

System	Key Requirement	FCF H/W	PI H/W	Compliance
Data	580 GB total image data	IOP; IPSU		Yes
	Up/Down link required to decide to proceed	IOP/ISS HRDL		Yes – sample of data will be sufficient
Resources	Volume – PF5060	Bench volume	Chamber size: 20X20X20 cm for PF	Yes
	Volume – H_2O	Bench volume	Chamber size: 35X35X75 cm for H_2O	TBD
	Mass – PF5060			Yes
	Mass – H_2O			TBD

Basis Experiment f12 – Critical Point Phenomena

Basis Experiment Science Summary

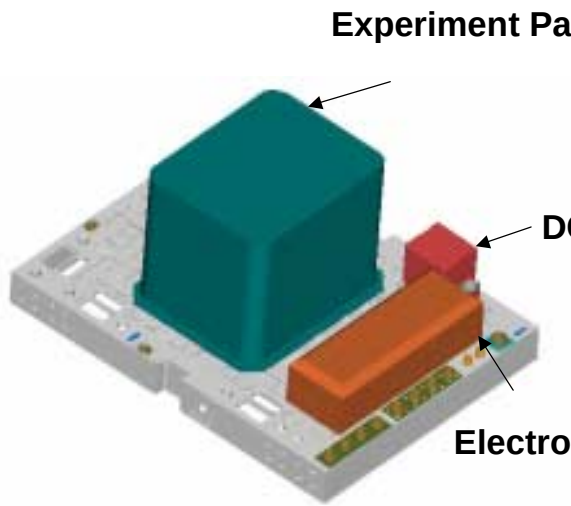
- PI: TBD
- PM: TBD

Experiment Summary

- Study of equilibrium and non-equilibrium transport and thermodynamic properties very close to the liquid-vapor critical point.

Key FIR - Experiment Interface Requirements

- Micro-gravity environment
- Temperature control
- Data management



Includes:
- **Test Cell**
- **Interferometer**
- **Access for Test Cell Change-out**
- **Cameras**
- **Lasers**
- **Folding Mirrors**
- **Coolant Water Access**

Compliance Summary: FCF design complies with SRED requirements for f12.

Basis Experiment f12 – Compliance Summary

System	Key Requirement	FCF H/W	PI H/W	Compliance
Hardware	Direct visualization of fluid	Analog camera White light		Yes
Experimental Environment (measurement and control)	Acceleration measurement Acceleration control G/G_0: DC: $<10^{-5}$ for 30 minutes Jitter $<10^{-3}$ for all freq	SAMS ARIS		Yes Yes – ARIS not expected to isolate jitter for all freq
	Pressure, Temperature	ATCU & FSAP	Sensor hardware, Signal conditioning, & S/W	Yes
Data	1,200 GB total image data	IOP; IPSU	Extra data storage, compression and/or on-board processing	Yes
Resources	Rack Mass: 740 kg Peak Power: 1,490 Watts Energy: 700 kW-hrs (includes max data downlink)			Yes

Basis Experiment f11A – Induced Instabilities (TCCE)

Basis Experiment Science Summary

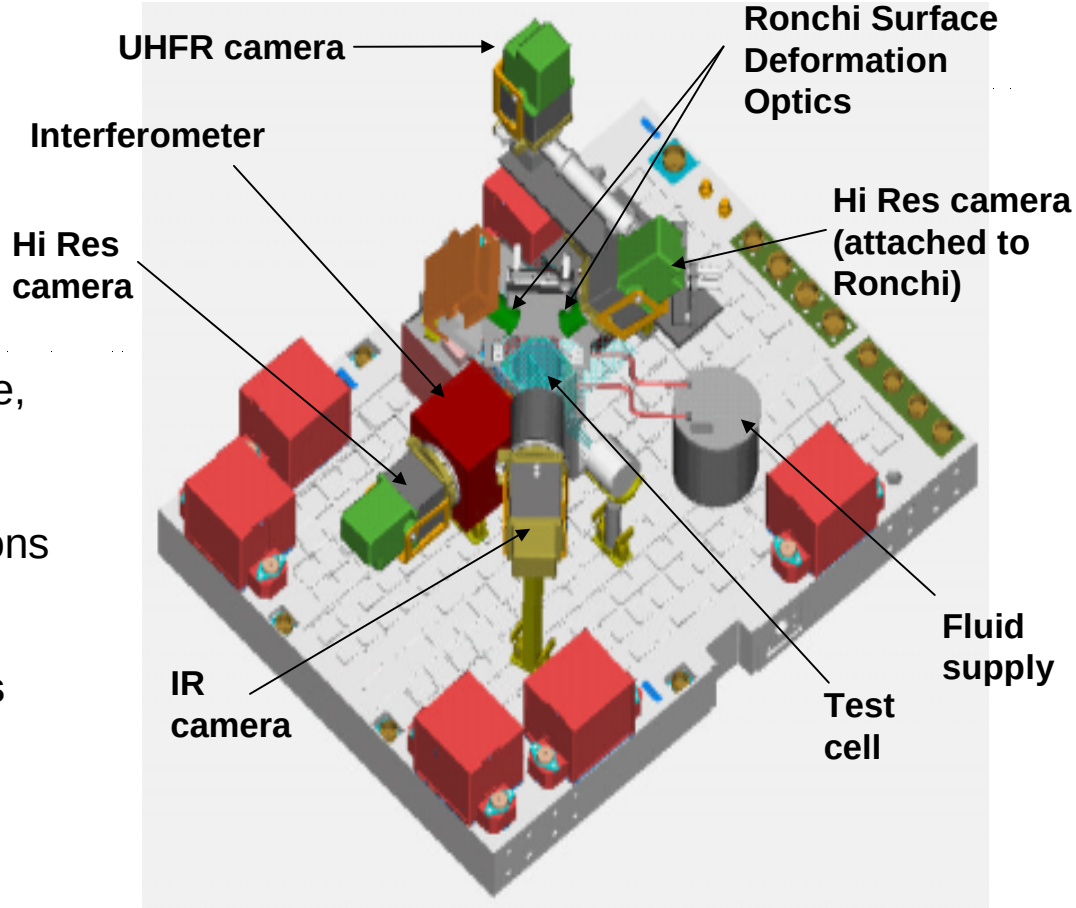
- PI:TBD
- PM:T. Jacobson (GRC)

Experiment Summary

- Study various phenomena resulting from surface tension variations on a free surface, including surface flows (and how they propagate into the bulk fluid), surface deformations, and determining the conditions which cause surface oscillations.

Key FIR - Experiment Interface Requirements

- Data management
- Peak power management



Compliance Summary: FCF design complies with SRED requirements for f11A. Data management within the experimental timeline is TBD. Management of short periods of peak power required.

Basis Experiment f11A (TCCE) – Compliance Summary

System	Key Requirement	FCF H/W	PI H/W	Compliance
Hardware	Velocity field	UHFR camera Nd:YAG laser	PIV optics	Yes
	Temperature field		IR camera	Yes
	Concentration field	Hi Res camera	Interferometer	Yes
	Surface deformations	Hi Res camera	Ronchi Optics	Yes
Experimental Environment (measurement and control)	Acceleration measurement Acceleration control G/G_0: DC: $<10^{-4}$ Jitter: no data	SAMS ARIS		Yes Yes
	Temperature: test cell range from 0 to 100°C; controlled to ±0.5°C; measured to ±0.1°C Pressure: ambient	ATCU & FSAP AMA	Sensor hardware, Signal conditioning, & S/W	Yes Yes
Data	5,039 GB total image data	IOP; IPSU	Extra data storage, compression and/or on-board processing	Yes
Resources	Avg Power: 1,872 Watts Peak Power: 2,135 Watts			Yes – management of power required
Resources	Rack Mass: 706 kg Energy: 774 kW-hrs (includes max data downlink)			Yes

Basis Experiment f11B – Induced Instabilities (IIE)

Basis Experiment Science Summary

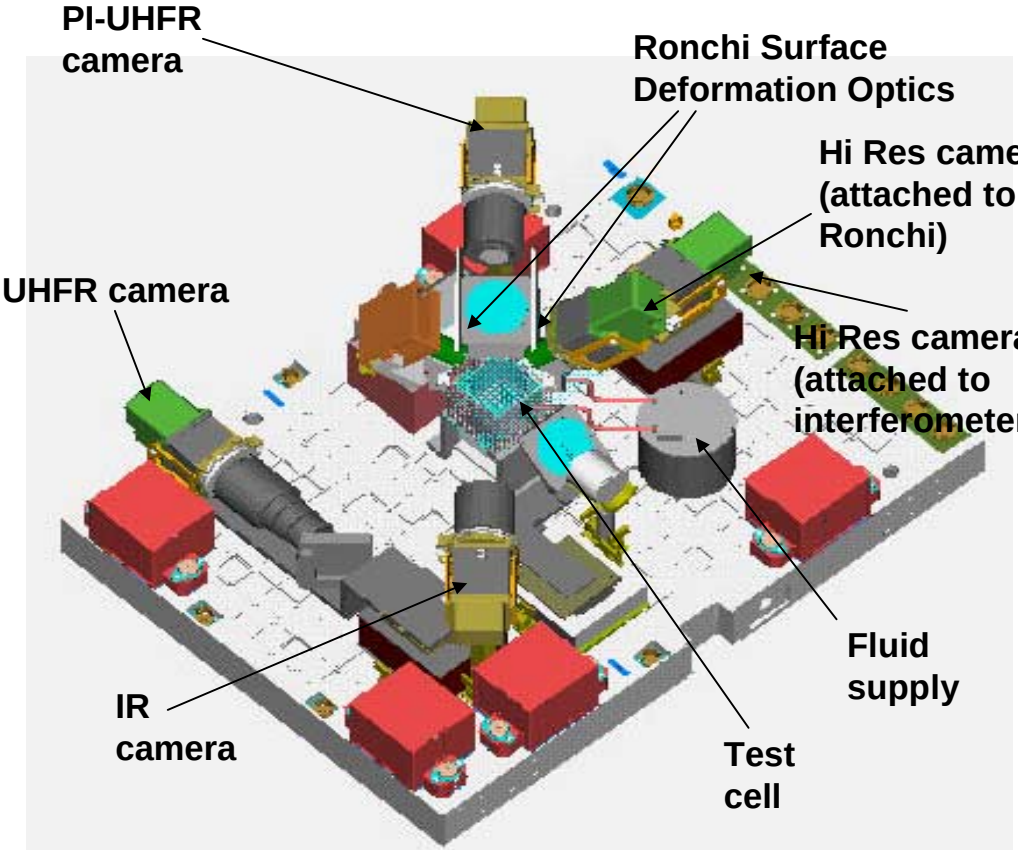
- PI:TBD
- PM:T. Jacobson (GRC)

Experiment Summary

- Study of various phenomena that result from a temperature gradient applied across a fluid interface especially to verify that such instabilities are surface-tension driven and not gravity-driven. Unlike TCCE, these temperatures gradients are applied perpendicular (not parallel) to fluid interface.

Key FIR - Experiment Interface Requirements

- Data management
- Power management



Compliance Summary: FCF design complies with SRED requirements for f11B. Data management within the experimental timeline is TBD. Management of peak power and total power required.

Basis Experiment f11B (IIE) – Compliance Summary

System	Key Requirement	FCF H/W	PI H/W	Compliance
Hardware	Velocity field (orthogonal views)	UHFR camera (2) Nd:YAG laser	PIV optics (2)	Yes
	Temperature field		IR camera	Yes
	Concentration field	Hi Res camera	Interferometer	Yes
	Surface deformations	Hi Res camera	Ronchi Optics	Yes
Experimental Environment (measurement and control)	Acceleration measurement Acceleration control G/G_0: DC: $<10^{-6}$; less if aligned Jitter: no data	SAMS ARIS		Yes Yes
	Temperature: test cell from 15 to 100°C; controlled to ±0.05°C; measure to ±0.01°C Pressure: ambient	ATCU & FSAP AMA	Sensor hardware, Signal conditioning, & S/W	Yes
Data	7,300 GB total image data	IOP; IPSU	Extra data storage, compression and/or on-board processing	Yes
Resources	Rack Mass: 790 kg (without extra hard drives) Energy: 770 kW-hrs (includes max data downlink)			Yes
Resources	Peak Power: 2,345 Watts Avg Power: 2,158 Watts			Yes -- management of power required

Basis Experiment f11C – Double Diffusion (DDE)

Basis Experiment Science Summary

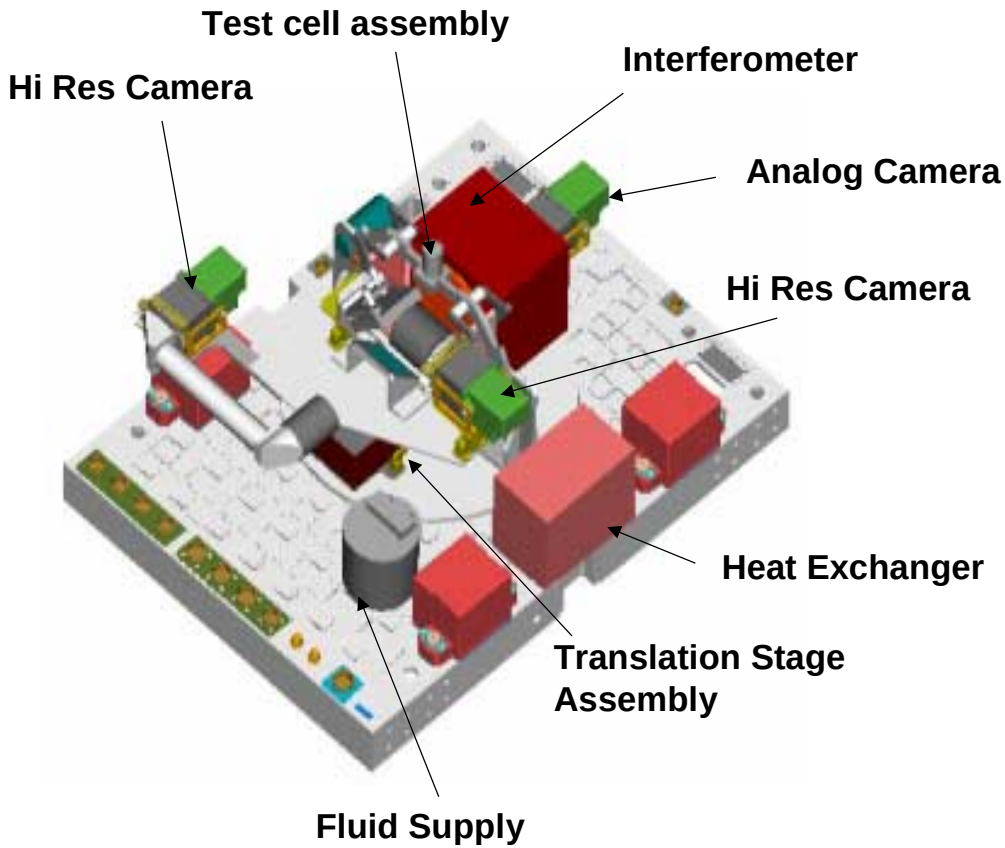
- PI: TBD
- PM: T. Jacobson (GRC)

Experiment Summary

- Study of flows that are generated by buoyancy due to thermocapillary gradients or due to the simultaneous presence of temperature and concentration gradients. (Latter case is referred to as double diffusive convection.)

Key FIR - Experiment Interface Requirements

- Alignment of test sample with G-vector



Compliance Summary: FCF design complies with SRED requirements for f11C.

Basis Experiment f11C (DDE) – Compliance Summary

System	Key Requirement	FCF H/W	PI H/W	Compliance
Hardware	Velocity field	Hi Res camera Nd:YAG laser	PIV optics	Yes
	Temperature field	Hi Res camera	Shadowgraphy	Yes
	Concentration field	Analog camera	Interferometer	Yes
Experimental Environment (measurement and control)	Acceleration measurement Acceleration control G/G_0: DC: none specified; G vector alignment required Jitter: no data	SAMS ARIS	 Orientation of test cell relative to G vector	Yes Yes
	Temperature: test cell range from 0 to 100°C; controlled to ±0.5°C; measured to ±0.1°C Pressure: ambient	ATCU & FSAP AMA	Sensor hardware, Signal conditioning, & S/W	Yes Yes
Data	242 GB total image data	IOP; IPSU		Yes
Resources	Rack Mass: 770 kg Avg Power: 1,772 Watts Peak Power: 1,900 Watts Energy: 483 kW-hrs (includes data downlink)			Yes

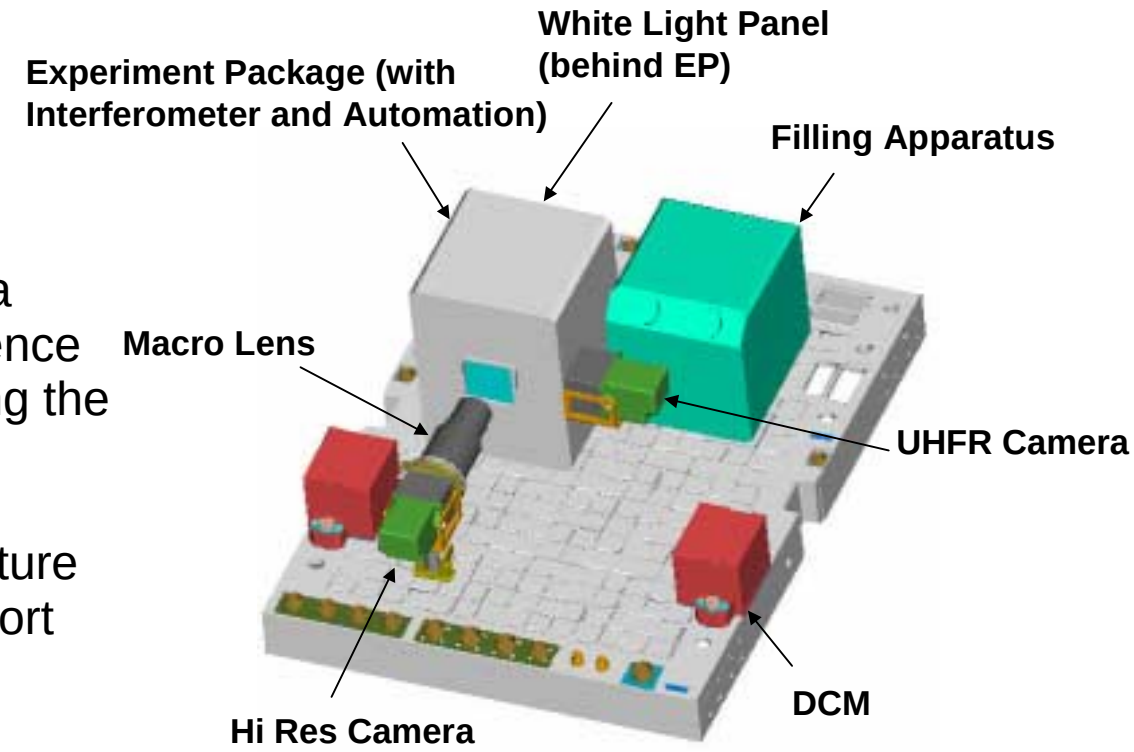
Basis Experiment f10 – Interfacial Transport and Micellar Solubilization

Basis Experiment Science Summary

- PI: Hatton
- PM:TBD

Experiment Summary

- Study of diffusion of a solute across a surfactant-laden interface in the absence of solutally driven convection including the effects of surfactant type and concentration, solvent type and concentration, solute molecular structure and temperature on interfacial transport processes.



Key FIR - Experiment Interface Requirements

- Power management

Compliance Summary: FCF design complies with SRED requirements for f10. Management of peak power periods required.

Basis Experiment f10 – Compliance Summary

System	Key Requirement	FCF H/W	PI H/W	Compliance
Hardware	Concentration field Surveillance	UHFR camera Nd:YAG laser Hi Res camera, macro lens	Interferometer	Yes Yes
Experimental Environment (measurement and control)	Acceleration measurement Acceleration control G/G_0: DC: $<10^{-3}$ Jitter: no data	SAMS ARIS		Yes Yes
	Temperature: test cell range from 10 to 35° C ±0.01°C Pressure: ambient	ATCU & FSAP AMA	measured in 5 locations near test cell	Yes Yes
Data	30 GB total image data	IOP; IPSU		Yes
Resources	Rack Mass: 765 kg Energy: 220 kW-hrs			Yes
Resources	Avg Power: 1,957 Watts Peak Power > 2,220 Watts			Yes -- management of power required

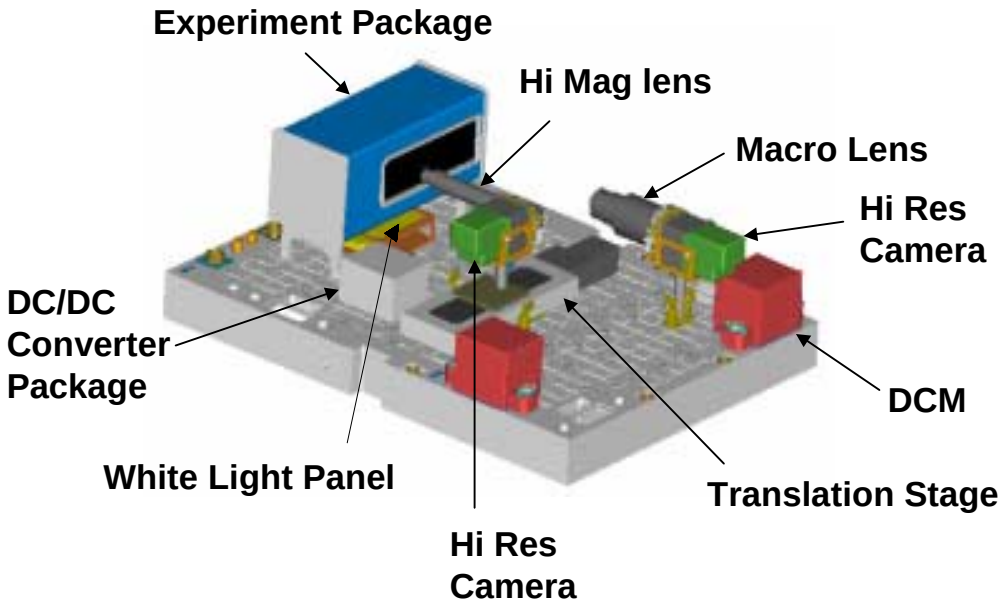
Basis Experiment f9 – Thermocapillary Motion of Bubbles and Drops

Basis Experiment Science Summary

- **PI: Davis**
- PM: TBD

Experiment Summary

- Study of thermocapillary migrations, coalescence, and subsequent phase segregation of bubbles and drops. Specific areas of interest include: growth rates of the segregated layer; characteristic times for the total coalescence of the disperse phase; and the study of the relative effects of migration versus coalescence.



Key FIR - Experiment Interface Requirements

- Power management

Compliance Summary: FCF design complies with SRED requirements for f9. Management of power required.

Basis Experiment f9 – Compliance Summary

System	Key Requirement	FCF H/W	PI H/W	Compliance
Hardware	Bubble images	Hi Res camera, white light panel	Translation device	Yes
	Velocity field	Hi Res camera,	PIV optics	Yes
	Temperature field	Analog camera	Interferometer	Yes
Experimental Environment (measurement and control)	Acceleration measurement Acceleration control G/G_0: DC: $<10^{-3}$ (alignment may be required) Jitter: isolation for freq<1 HZ	SAMS ARIS	PI to provide alignment with G vector if required	Yes
	Temperature: -20 to +120° C ±1°C with uniform gradient; transverse variations <0.1°C; maximum gradient expected is 3°C.	ATCU & FSAP	Heater, Sensor hardware, Signal conditioning, & S/W	Yes
Data	723 GB total image data	IOP; IPSU		Yes
Resources	Peak Power > 2,345 Watts Avg Power: 2,085 Watts			Yes -- management of power required
Resources	Rack Mass: 777 kg Energy: 673 kW-hrs (including data downlink)			Yes

Basis Experiment f8 – Interactions of Bubbles and Drops

Basis Experiment Science Summary

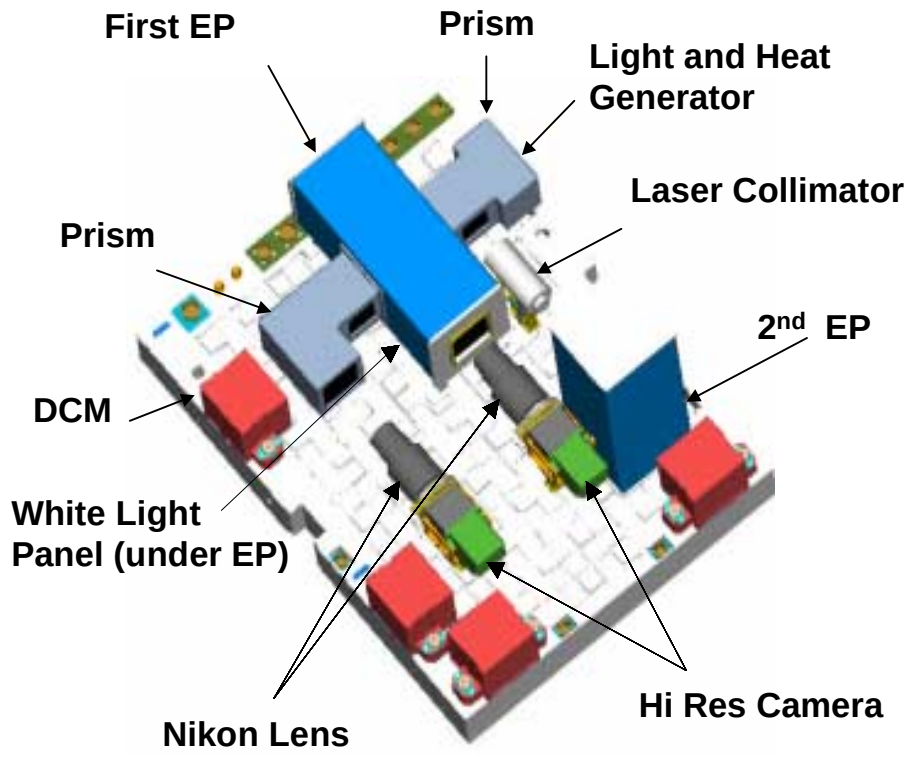
- PI: Subramanian
- PM:TBD

Experiment Summary

- Study thermocapillary migrations of bubbles and drops in fluids, including change in interfacial tension as a function of temperature gradient and dynamic viscosity as a function of velocity.

Key FIR - Experiment Interface Requirements

- Data management
- Power management



Compliance Summary: FCF design complies with SRED requirements for f8. Data management within the experimental timeline is TBD. Management of power required.

Basis Experiment f8 – Compliance Summary

System	Key Requirement	FCF H/W	PI H/W	Compliance
Hardware	Bubble images	Hi Res camera, white light panel	Translation device	Yes
	Velocity field	Hi Res camera,	PIV optics/diagnostics	Yes
	Temperature field	Analog camera Nd:YAG laser	Interferometer	Yes
Experimental Environment (measurement and control)	Acceleration measurement Acceleration control G/G_0: DC<10^{-5} jitter <10^{-5} for freq <0.01 HZ	SAMS ARIS		Yes Yes
	Temperature: -20 to +120° C ±1°C with uniform gradient; transverse variations <0.1°C; longitudinal gradient variation <±1°C in the EP	ATCU & FSAP AMA	Heaters, Sensor hardware, Signal conditioning, & S/W	Yes Yes
Data	7,110 GB total image data	IOP; IPSU	Extra data storage, compression and/or on-board processing	Yes
Resources	Rack Mass: 773 kg (without extra hard drives) Energy: 886 kW-hrs (includes max data downlink)			Yes -- management of power required
Resources	Peak Power: 2,310 Watts Avg Power: 2,004 Watts			Yes -- management of power required

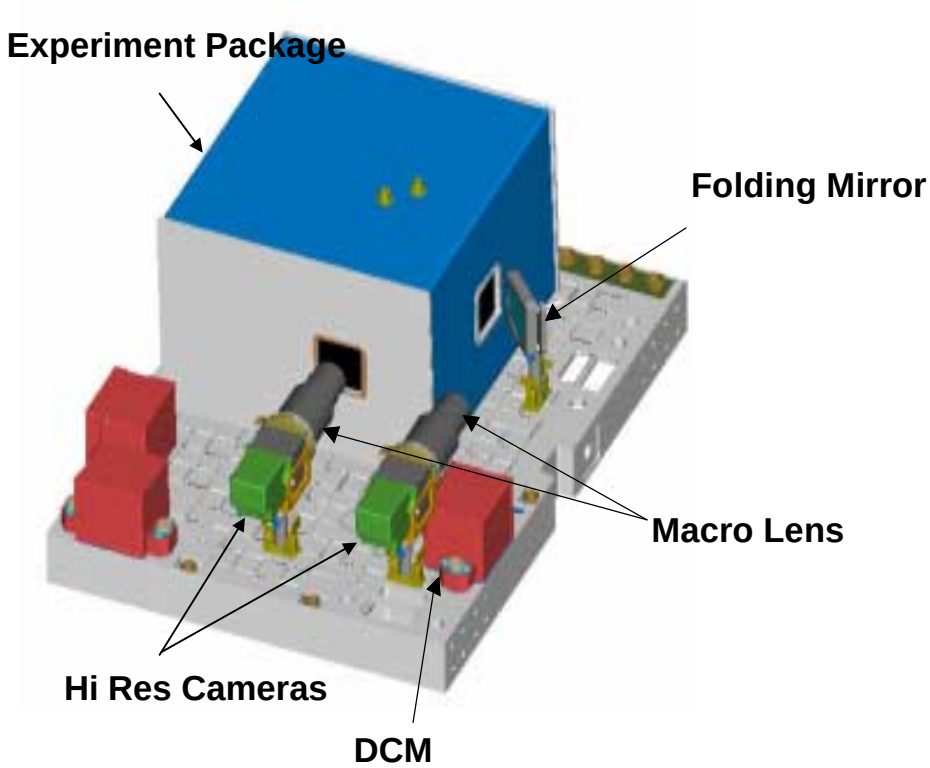
Basis Experiment f7 – Nucleation and Growth of Microporous Crystals

Basis Experiment Science Summary

- PI:Dutta
- PM:D. Frate

Experiment Summary

- Study 3 types of crystal growth of microporous materials:
  - layer-by-layer type of growth
  - Sigmoid type of growth
  - solid state reconstruction type of growth



Key FIR - Experiment Interface Requirements

- Data management

Compliance Summary: FCF design complies with SRED requirements for f7. Data management within the experimental timeline is TBD.

Basis Experiment f7 – Compliance Summary

System	Key Requirement	FCF H/W	PI H/W	Compliance
Hardware	Visual imaging & Light scattering	Hi Res camera (2) Macro lens (2) White light	Light scattering optics	Yes
Experimental Environment (measurement and control)	Acceleration measurement Acceleration control G/G_0: DC: $<10^{-4}$ Jitter: no data	SAMS ARIS		Yes Yes
	Pressure & Temperature: ambient	AMA		Yes
Data	63,420 GB total image data	IOP; IPSU	Extra data storage, compression and/or on-board processing	Yes
Resources	Rack Mass: 767 kg Energy: 746 kW-hrs (includes max data downlink)			Yes
Resources	Peak Power: 2,180 Watts Avg Power: 1,920 Watts			Yes-- management of power required

Basis Experiment f6 – Studies in Electrohydrodynamics

Basis Experiment Science Summary

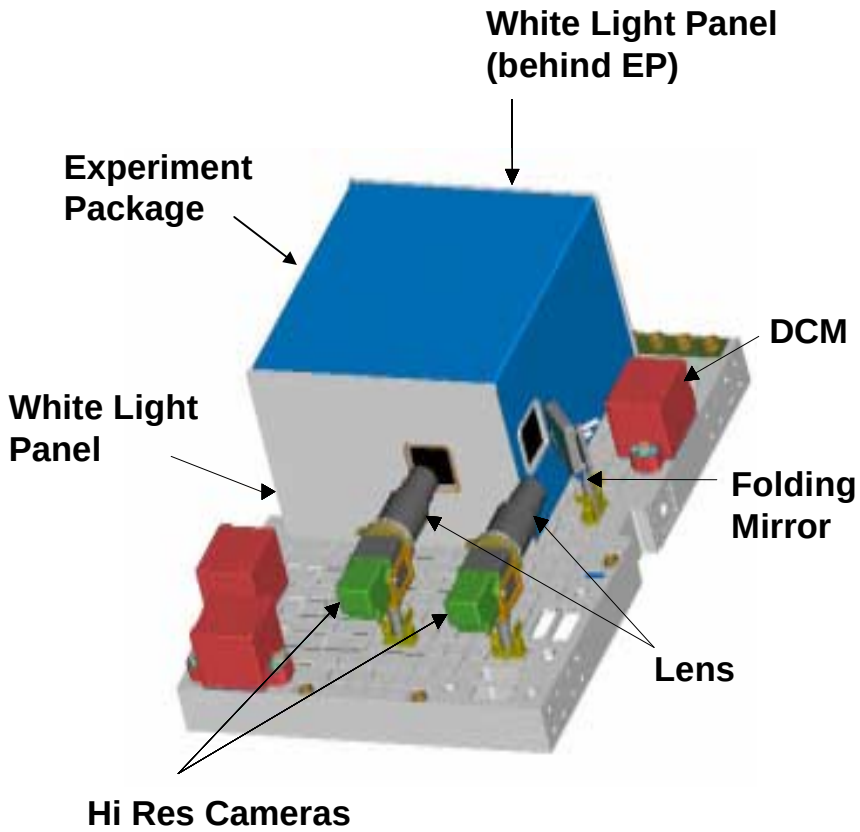
- PI: Saville
- PM:TBD

Experiment Summary

- Study of cylindrical shape, shape dynamics, and pinch off characteristics of a column of liquid in a strong electric field.

Key FIR - Experiment Interface Requirements

- Data management
- Power management
- Measurement and control of large electric fields



Compliance Summary: FCF design complies with SRED requirements for f6. Data management within the experimental timeline is TBD. Management of peak power and total power required.

Basis Experiment f6 – Compliance Summary

System	Key Requirement	FCF H/W	PI H/W	Compliance
Hardware	Visual image; two orthogonal views	Hi Res camera (2) Macro lens (2) White light		Yes
Experimental Environment (measurement and control)	Acceleration measurement Acceleration control G/G_0: DC: $<10^{-5}$ for 45 minutes DC: $<10^{-4}$ for 60 minutes Jitter: no data	SAMS ARIS		Yes Yes
	Pressure & Temp: ambient Voltage measurement from 0 to 20,000 volts controlled to ±5% (0-5 kV/cm and 0-500 Hz AC). Capability to measure very small currents	AMA ATCU & FSAP	Voltage set up	Yes Yes
Data	3,100 GB total image data	IOP; IPSU	Extra data storage, compression and/or on-board processing	Yes
Resources	Peak Power: 2,345 Watts Avg Power: 2,085 Watts			Yes – management of power required
	Rack Mass: 769 kg Energy: 368 kW-hrs (includes max data downlink)			Yes

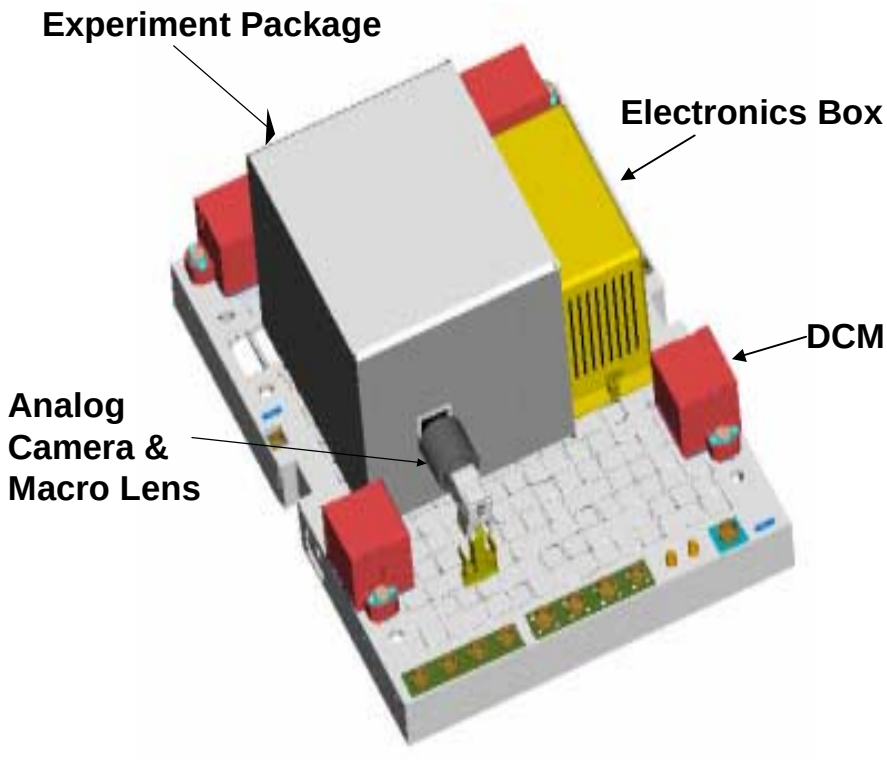
Basis Experiment f5 – Colloid Physics

Basis Experiment Science Summary

- PI: David Weitz (Harvard)
- PM: J. Koudelka (GRC)

Experiment Summary

- Study of nucleation, growth, coarsening of crystal structures as well as rheological structural properties of binary alloys (highly ordered) and fractal aggregates (highly disordered structures).



Compliance Summary: FCF design complies with SRED requirements for f5.

Basis Experiment f5 – Compliance Summary

System	Key Requirement	FCF H/W	PI H/W	Compliance
Hardware	Visual Imaging	Analog Camera	White light	Yes
	Bragg scattering	Nd:YAG laser	Digital camera Collimator Wide angle lens	Yes
	DLS/SLS		Laser, APD (2)	Yes
Experimental Environment (measurement and control)	Acceleration measurement Acceleration control G/G_0: DC: $<10^{-3}$ Jitter: no data	SAMS ARIS		Yes
	Pressure, Temperature: ambient	AMA		Yes
Data	187 GB total image data	IOP; IPSU		Yes
Resources	Rack Mass: 753 kg Peak Power: 1,535 Watts Energy: 573 kW-hrs (includes data downlink)			Yes

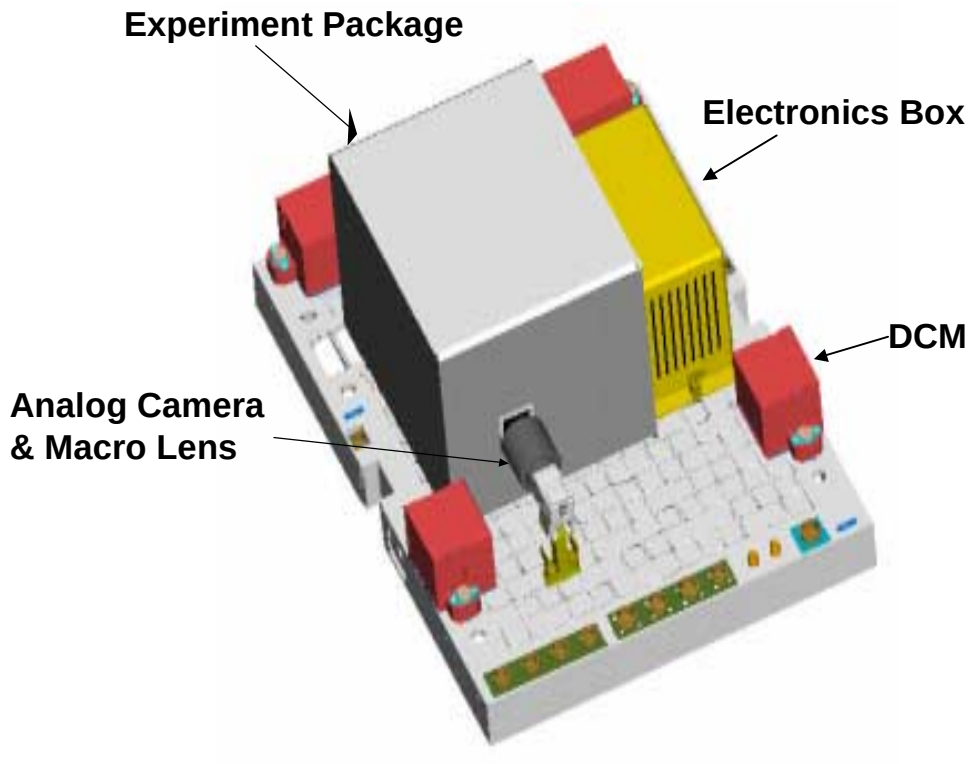
Basis Experiment f4 – Dynamics of Hard Sphere Colloids

Basis Experiment Science Summary

- PI:Paul Chakin (Princeton)
- PM: J. Koudelka (GRC)

Experiment Summary

- Study of nucleation, growth, and rheological properties of a hard sphere colloidal suspension, including measurement of kinetic and equilibrium structures for suspension at various volume fractions to identify the various liquids, crystal, and glass states and their transition regions.



Compliance Summary: FCF design complies with SRED requirements for f4.

Basis Experiment f4 – Compliance Summary

System	Key Requirement	FCF H/W	PI H/W	Compliance
Hardware	Visual Imaging (cell 1)	Analog Camera	White light	Yes
	Visual Imaging (cell 2)	White light	Analog camera	Yes
	Bragg scattering (hi/lo angle)	Nd:YAG laser	Digital camera (2) Collimator Wide angle lens Micro lens	Yes
	DLS/SLS		Nd:YAG laser, APD (2)	Yes
Experimental Environment (measurement and control)	Acceleration measurement Acceleration control G/G_0: DC: $<10^{-3}$ Jitter: no data	SAMS ARIS		Yes Yes
	Pressure, Temperature: ambient	AMA		Yes
Data	935 GB total image data	IOP; IPSU		Yes
Resources	Rack Mass: 753 kg Peak Power: 1,480 Watts Energy: 785 kW-hrs (includes max data downlink)			Yes

Basis Experiment f3 – Rheology of Non-Newtonian Fluids

Basis Experiment Science Summary

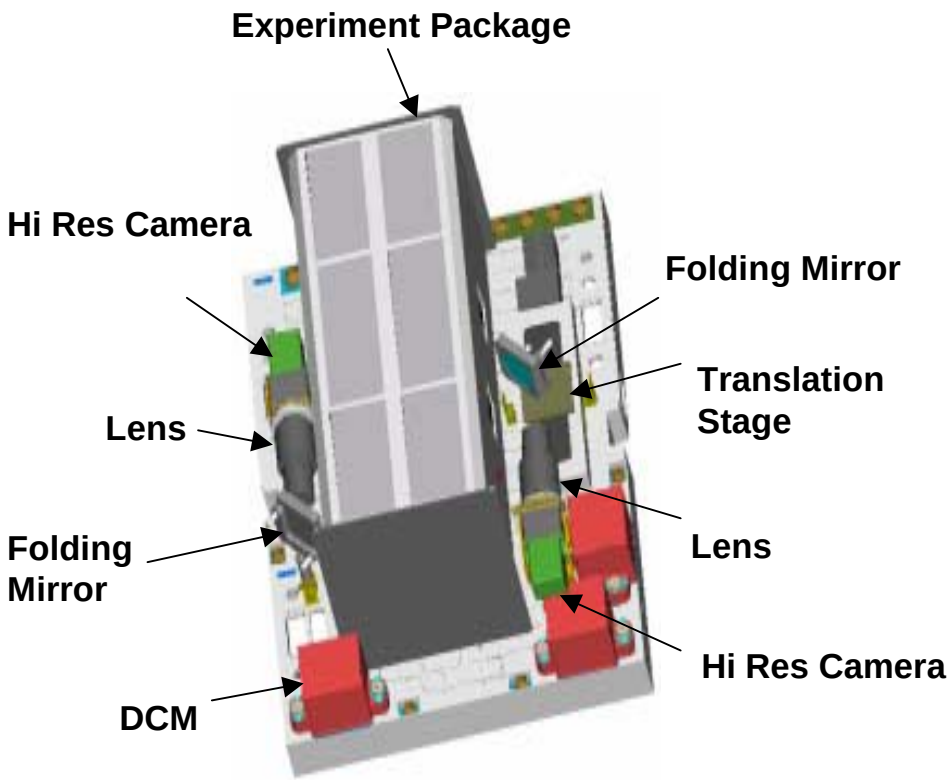
- PI: McKinley
- PM: K. Logsdon (GRC)

Experiment Summary

- Study uniaxial extensional viscosity of a "Bolgar fluid." The experimental package (EP) needs to generate a smooth, stable, cylindrical bridge, which will impose a constant strain rate (which can be varied) on the fluid element.

Key FIR - Experiment Interface Requirements

- Design of experimental package which fits on the bench and accommodates the science requirements for stretching the fluid.



Compliance Summary: FCF design does NOT comply with SRED requirements for f3; length of the FIR bench is insufficient to accommodate the science requirements

Basis Experiment f3 – Compliance Summary

System	Key Requirement	FCF H/W	PI H/W	Compliance
Hardware	Velocity field Column View	Hi Res camera Nd:YAG laser Hi Res camera white light panel	PIV optics	Yes Yes
Experimental Environment (measurement and control)	Acceleration measurement Acceleration control G/G_0: DC: < 0.018 Jitter: <0.018 for freq < 5HZ <0.03 for freq > 5 HZ	SAMS ARIS		Yes Yes
	Pressure, Temperature, Air Flow	ATCU & FSAP	Sensors, controllers	Yes
Data	94 GB of total image data	IOP; IPSU		Yes
Resources	Bench Volume		Experimental package longer than the bench	No
	Rack Mass: 778 kg Peak Power: 1,985 Watts Energy: 34 kW-hrs (including data downlink)			Yes

Microscale Hydrodynamics Near Moving Contact Lines [for f2]

Basis Experiment Science Summary

- PI: Steve Garoff (Carnegie Mellon) and Michelle Louge (Cornell)
- PM: Amy Jankovsky (GRC)

Experiment Summary

- Study of flow fields and interface shapes very close to a dynamic contact line, moving at constant velocity in the geometry-independent region.

Key FIR - Experiment Interface Requirements

- Bench volume; experiment needs as long a cell as possible

Compliance Summary: FCF design accommodates all interface requirements; design of PI test cell to maximize length within the constraints of the bench volume will be an engineering challenge.

Microscale Hydrodynamics Near Moving Contact Lines – Compliance Matrix

System	Key Requirement	FCF H/W	PI H/W	Compliance
Hardware	Imaging C/L Imaging interface	Hi Res Camera (FCF BSD B.2.3.5.1.1) IPSU	High Mag Len Hi Res Camera Macro Lens Interface to IPSU	Yes Yes -- PULNEX camera considered due to alignment and resolution concerns
	On-orbit Processing: may be necessary for data reduction Tracking/Positioning: required for the micro and macro views Views: simultaneous micro and macro view	IPSU (FCF BSD 5.2.5) FSAP (FCF BSD B2.3.7)	Tracking Mechanism	Yes –FCF will simultaneous image micro/macro views. Yes -- PI to provide the capability to track and keep C/L in micro FOV
	Kohler light source for general imaging (interface shape & C/L)		Kohler light source	Yes
	Laser required for PIV diagnostic (TBD char)		500 mW pulsed laser is required	Yes

Microscale Hydrodynamics Near Moving Contact Lines – Compliance Matrix – Continued

System	Key Requirement	FCF H/W	PI H/W	Compliance
Experimental Environment (measurement and control)	Acceleration measurement Acceleration control: $G/G_0<10^{-4}$ aligned; Jitter: sensitive to freq in 0.2 - 2.0 Hz range	SAMS (FCF BSD 5.1.4) ARIS (FCF BSD 5.3)		Yes Yes
	Temperature: at least one measurement controlling +/- 0.05 deg-C (in range of 20 to 30 deg-C) for all samples	FSAP (FCF BSD B2.3.7)	Sensors, controllers Signal conditioning	Yes
	Pressure: at least one measurement controlling to around 1 atm, +/- 1.0 psia	FSAP (FCF BSD B2.3.7)	Sensors, controllers	Yes
	Voltage: 10 to 20 health and status meas. @ 30 Hz	AMA (FCF BSD B2.3.10)		Yes
	Relative humidity must be less than 6% interior to cell	AMA (FCF BSD B2.3.10)	Local humidity measurement	Yes
	Water: to establish desired thermal conditions	Lines and QD's if used	Lines, QD's, and HX	Yes – if needed
	GN2: maybe used	Gas Interface Panel (FCF BSD B.2.3.9)	Control valves, QD's	Yes – if needed
	Venting / Vacuum: Maybe required if GN2 is used	Vent resources (FCF BSD 3.0)	Control valves, QD's	Yes – if needed

Microscale Hydrodynamics Near Moving Contact Lines – Compliance Matrix – Continued

System	Key Requirement	FCF H/W	PI H/W	Compliance
Data	Data Duration: approx. 500 sec. at 2 fps and about 20 sec. at 30 fps per exp run. Total # of Tests: about 40 tests of varying fluids, and rod velocities. 3.36 GB per exp run 134. GB total (40 runs)	IOP (FCF BSD 5.2.4)		Yes
	"Real-time" required for health and status data Post test: most if not all image processing (e.g., of PIV) done on ground	IOP/ISS HRDL (FCF BSD 3.0)		Yes -- A sampling of data from each run to be downlinked prior to next run
Resources	Volume PI Mass – 40 to 60 kg Power – TBD Energy – TBD	Bench volume	EP: ~25 cm width; ~75 cm length	Yes – Experiment needs as long a cell dimension as possible
	Test Durations: ~500 sec transient data, 20 sec of steady state Total # of tests: ~40 (various rod velocities, fluids, surface conditions, 6 cells total			Yes -- Time between tests may be determined by amount/speed of downlinked.

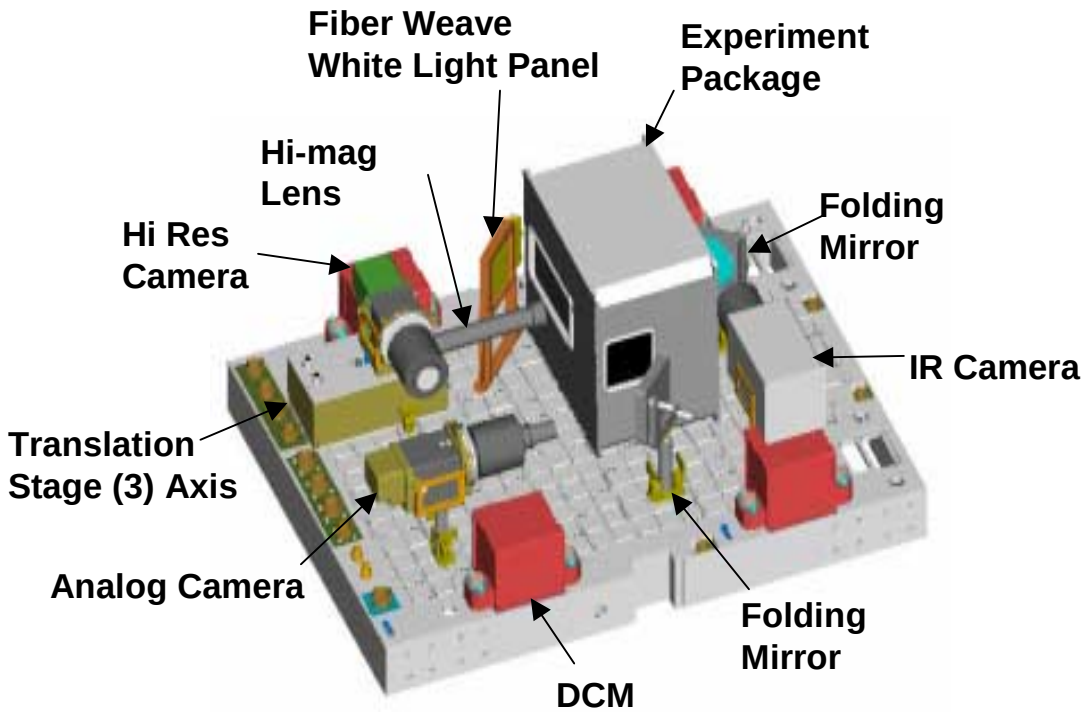
Basis Experiment f1 – Thin Film Fluid Flows at Menisci

Basis Experiment Science Summary

- PI:Hallinan
- PM:TBD

Experiment Summary

- Measure evaporation from a capillary meniscus in micro-gravity, which will extend the range of influence of the solid-liquid intermolecular interaction to film dimensions so that optical techniques can be applied.
- Shape and thickness of meniscus are measured as well as the velocity profile within the meniscus as a function of temperature.



Key FIR – Experiment Interface Requirements

- Data management

Compliance Summary: FCF design complies with SRED requirements for f1 assuming data compression, on-board processing, PI provided hard drive and/or other means of data management.

Basis Experiment f1 – Compliance Summary

System	Key Requirement	FCF H/W	PI H/W	Compliance
Hardware	Surveillance Contact line Film thickness Temperature fields Velocity fields	Analog camera Hi Res cam,HiMag lens Nd:YAG laser White light & panel IPSU, FSAP	Lens for microscopy view IR camera, interferometer & lens Specific optics for focusing illumination	Yes
Experimental Environment (measurement and control)	Acceleration measurement Acceleration control G/G_0: DC: $<10^{-3}$ aligned; $<10^{-6}$ unaligned Jitter: isolate for freq < 10 HZ	SAMS ARIS		Yes Yes -- PI to orient EP
	Pressure, Temperature, Air Flow	ATCU & FSAP AMA	Monitoring & control of test cells (tc's)	Yes
Data	5.5 TB total image data	IOP; IPSU	Extra data storage, compression and/or on-board processing	Yes
Resources	Rack Mass: 778 kg (without extra hard drives) Peak Power: 1,930 Watts Energy: 455 kW-hrs (including data downlink)			Yes

Fluids Basis Experiments – Utilization of FCF provided hardware

BASIS EXP HARDWARE	f1	f2	f3	f4	f5	f6	f7	f8	f9	f10	f11A	f11B	f11C	f12	f13A	f13B	-- f14 --	f15A	f15B	------- f16 ------	% Util
Hi-Res Cam #1	1	1	1			1	1	1	1	1	1	1	1		1	1	1	1	1	1	85%
Hi-Res Cam #2		1	1				1	1	1		1	1	1			1		1		1	55%
Color Camera	1	1		1	1			1	1	1			1			1	1			1	55%
UHFR Camera						1				1	1	1			1		1	1			35%
NdYAG Laser	1	1	1	1	1			1		1	1	1	1		1	1			1	1	70%
Laser coll (2)								1													3%
White Light	1	1	1	1		1	1	1	1	1	1	1			1	1	1	1	1	1	85%
Fiber Weave Panel	1		1			2		1	1	1	1	1			1	1	1				60%
Diode Lasers (2)							1	1													10%
Gimbal Mirror	1		1			1	1		1		1	1			1	1		1			50%
Micro Lens (Optum)	1	1				1			1		1	1						1	1		40%
Macro Lens-Nikon (2)		1	2			1	2	2	1	1	1	2	2		2	1	1	1			50%
Color lens (Navitar)	1			1	1			1	1	1							1	1			40%
XYZ Trans	1	1	1								1	1	1		1	1			1		45%
ARIS	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	100%
SAMS Head	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	100%
Vent/Vacuum										1								1	1	1	20%
Water	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	90%
ATCU	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	100%
Fire Suppression	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	100%
IPSUs & FSAP	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	100%

Fluids Basis Experiments – Utilization of PI provided hardware

BASIS EXP HARDWARE	f1	f2	f3	f4	f5	f6	f7	f8	f9	f10	f11A	f11B	f11C	f12	f13A	f13B	-- f14 --	f15A	f15B	------- f16 ------
IR Camera & lens	1										1	1								
Additional Analog Camera				1								1					1			1
Additional Digital Cameras																				
PI Specific Digital Cameras				2	1															
Translation/Rot. Stage		3	4	2	2	1	1	1	1		2	4	4		3	2	1	1		
Additional Motor/controller		1	1	2	1	1	1						1				1			20
Light Sheet Optics		1	2					1			1	2	1		2		1			
Collimator				1	1			1						2		1				
Laser diode			2				1													
Additional Laser				1	1						1	1		1						1
Mirror/IR Mirror	1	3	1	2	1			2	2					3	1		2	2		
Wide Angle Lens				1	1							1				1				1
Hi-mag or other lens		1		1							1		1				1			
Bulb/LED-PI provided				2	2												2			
Heaters	1							2	2		1	1	1							
Coolers											1	1	1							
fluid dispens/pump/manage	1	1	1			1		1	1	1	1	1	1		1				1	
Correlator Card				1	1		1													
Fiber ring light/bundle		1											1				2	1	1	
Vent Control Valves										1					1	1				1
Water Connection/valves	1			1	1											1				
GN2 Control Valves								1	1	1					1	1				
Additional PI Optic Pack.		2	3	3	3		2	4		2	2	3	3	6		1		1	1	4

Fluids Real Experiments – Utilization of FCF provided hardware

REAL EXP HARDWARE		C/L														Pool Boil	µgSEG	SiGMA	MOBI	FOAM	LΦCA	CVB	PHaSE-2	PCS-2	% Util
Hi-Res Cam #1		1														1			1	1					40%
Hi-Res Cam #2																1									10%
Color Camera																	1	1	1	1	1	1	1	1	80%
UHFR Camera																	1	1	1		1	1	1	1	70%
NdYAG Laser																1		1		1	1		1	1	60%
Laser coll (2)																									0%
White Light (2)																1	1	1	2	1	1		1	1	90%
Fiber Weave Panel																1				1					20%
Diode Lasers (2)																									0%
Gimbal Mirror																1			1						20%
Micro Lens (Optum)		1																		1					20%
Macro Lens-Nikon (2)																2	1	1	1	1					30%
Color lens (Navitar)																									0%
XYZ Trans																									0%
ARIS		1														1	1	1	1	1		1			70%
SAMS Head		1														1	1	1	1	1	1	1	1	1	100%
Vent/Vacuum																1	1	1	1	1	1	1	1	1	90%
Water		1														1			1	1		1			50%
ATCU		1														1	1	1	1	1	1	1	1	1	100%
Fire Suppression		1														1	1	1	1	1	1	1	1	1	100%
IPSUs & FSAP		1														1	1	1	1	1	1	1	1	1	100%

Fluids Real Experiments – Utilization of PI provided hardware

REAL EXP HARDWARE		C/L														Pool Boil	µgSEG	SiGMA	MOBI	FOAM	LΦCA	CVB	PHaSE-2	PCS-2
IR Camera & lens																								
Additional Analog Camera																					1		1	1
Additional Digital Cameras																								
PI Specific Digital Cameras		1																						
Translation/Rot. Stage		3														1			1	1				
Additional Motor/controller		1															2	2			20	20	20	20
Light Sheet Optics																								
Collimator																								
Laser diode																								
Additional Laser		1																					1	1
Mirror/IR Mirror																	2	2						
Wide Angle Lens																1	1	1	1	1	1		1	1
Hi-mag or other lens		2																				1		
Bulb/LED-PI provided		1															1	1	1			1		
Heaters																1						1		
Coolers																						1		
fluid dispens/pump/manage																1				1				
Correlator Card																				1				
Fiber ring light/bundle																	1	1						
Vent Control Valves		1														1			1	1	1	1	1	1
Water Connection/valves		1														1	1	1		1		1		
GN2 Control Valves		1														1			1	1				
Additional PI Optic Pack.																1	1	1		2	4	1	3	4